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Development Document for Effluent Limitations Guidelines and Standards for the Electrical and Electronic Components Point Source Category. Phase II

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(Phase II)

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This document presents the findings of the EPA Phase II study of the Electrical and Electronic Co,ponents Point Source Category. THe Phase II study examines the electron tubes and luminiscent materials subcategories of ECEL, the document (1) explains which subcategories and pollutants are regulated/and which are no; (2) discusses the reasons; and (3) explains how the limitations were developed.

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for the

ELECTRICAL AND ELECTRONIC COMPONENTS POINT SOURCE CATEGORY
PHASE 2

Anne M. Gorsuch
Administrator

Steven Schatzow
Director
Office of Water Regulations and Standards

Jeffery Denit, Director
Effluent Guidelines Division

G. Edward Stigall, Chief
Inorganic Chemicals Branch

John Newbrough
Project Officer

February, 1983

U.S. Environmental Protection Agency
Office of Water
Office of Water Regulations and Standards
Effluent Guidelines Division
Washington, D.C. 20460

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EXECUTIVE SUMMARY

CONCLUSIONS

A study of the Electrical and Electronic Components Industrial Point Source Category Phase II was undertaken to establish discharge limitations guidelines and standards. The industry was subcategorized into segments based on product type. Of the three subcategories, one has been excluded under Paragraph 8 of the NRDC Consent Decree, and for two subcategories, regulations are being proposed. The two subcategories are Cathode Ray Tubes and Luminescent Materials. The Agency is proposing not to regulate existing direct dischargers for the reasons described in Section VI of this document. Therefore, BPT, BAT, and BCT effluent limitations are not being proposed.

In the Cathode Ray Tube subcategory the pollutants of concern include cadmium, chromium, lead, zinc, toxic organics, fluoride, and total suspended solids. Cadmium and Zinc are the major toxic metals found in phosphors in cathode ray tubes. Sources of these metals are manufacture, salvage, and phosphor recovery operations. Chromium occurs as dichromate in photosensitive materials and is found in wastewater from manufacture and salvage operations. Lead is found in the wastewater from the tube salvage operation where the lead frit is dissolved in nitric acid. Toxic organics occur from the use of solvents in cleaning and degreasing operations. The major source of fluoride is the use of hydrofluoric acid for cleaning and conditioning glass surfaces. Finally, total suspended solids result primarily from the use of graphite emulsions used to coat the tubes.

For the Luminescent Materials subcategory the pollutants of concern include cadmium, antimony, zinc, fluoride, and total suspended solids. Cadmium and zinc are major constituents of blue and green phosphors, and are found in the wastewater from washing and filtering operations. Antimony is used as an activator and found in the wastewater from lamp phosphor manufacture. Fluoride results from the manufacture of an intermediate lamp phosphor, calcium fluoride. Total suspended solids occur in wastes from washing and filtration operations.

Several treatment control technologies applicable to the reduction of pollutants generated by the manufacture of cathode ray tubes and luminescent materials were evaluated, and the costs of these technologies were estimated. Pollutant concentrations achievable through the implementation of these technologies were based on industry data. These concentrations are presented below as proposed standards for the Cathode Ray Tubes and Luminescent Materials subcategories.

PROPOSED EFFLUENT LIMITATIONS AND STANDARDS

Tables 1 through 5 present proposed regulations for New Source Performance Standards (NSPS), and Pretreatment Standards for New and Existing Sources (PSNS and PSES). All standards are expressed as milligrams per liter.

TABLE 1: PSES PROPOSED REGULATIONS FOR CATHODE RAY TUBES

Pollutant	Daily Maximum (mg/l)	Monthly Average (mg/l)
Cadmium	0.046	0.022
Chromium	0.91	0.26
Lead	1.13	0.36
Zinc	2.06	0.49
TTO	0.15	
Fluoride	32.6	22.3

TABLE 2: NSPS PROPOSED REGULATIONS FOR CATHODE RAY TUBES

Pollutant	Daily Maximum (mg/l)	Monthly Average (mg/l)	pH Range
Cadmium	0.046	0.022	
Chromium	0.77	0.22	
Lead	0.73	0.23	
Zinc	1.18	0.28	
TTO	0.15		
Fluoride	32.6	22.3	
TSS	42.9	16.1	
pH			6-9

TABLE 3: PSNS PROPOSED REGULATIONS FOR CATHODE RAY TUBES

Pollutant	Daily Maximum (mg/l)	Monthly Average (mg/l)
Cadmium	0.046	0.022
Chromium	0.77	0.22
Lead	0.73	0.23
Zinc	1.18	0.28
TTO	0.15	
Fluoride	32.6	22.3

TABLE 4: NSPS PROPOSED REGULATIONS FOR LUMINESCENT MATERIALS

Pollutant	Daily Maximum (mg/l)	Monthly Average (mg/l)	pH Range
Cadmium	0.48	0.23	
Antimony	0.18	0.044	
Zinc	2.84	0.68	
Fluoride	32.6	22.3	
TSS	61.0	22.9	
pH			6-9

TABLE 5: PSNS PROPOSED REGULATIONS FOR LUMINESCENT MATERIALS

Pollutant	Daily Maximum (mg/l)	Monthly Average (mg/l)
Cadmium	0.48	0.23
Antimony	0.18	0.044
Zinc	2.84	0.68
Fluoride	32.6	22.3

SECTION 1

INTRODUCTION

The purpose of this document is to present the findings of the EPA Phase 2 study of the Electrical and Electronic Components (E&EC) Point Source Category. The Phase 2 study examines the Electron Tubes and Luminescent Materials (Phosphorescent Coatings) subcategories of E&EC, the two subcategories which were previously deferred from regulatory analysis. EPA 440/1-82/075b July 1982.* The document (1) explains subcategories and pollutants are regulated and which are not; (2) discusses the reasons; and (3) explains how the actual limitations were developed. Section 1 describes the organization of the document and reviews the sources of industry data that were used to provide technical background for the limitations.

1.1 ORGANIZATION AND CONTENT OF THIS DOCUMENT

Data provided by industry are used throughout this report in support of regulating subcategories or excluding subcategories from regulation under Paragraph 8 of the NRDC Consent Decree. Telephone contacts, the literature, and plant visits provided the information used to subcategorize the industry in Section 3. These data were also considered in characterizing the industry in Section 4, Description of the Industry.

Water use and wastewater characteristics in each subcategory are described in Section 5 in terms of flow and pollutant concentration. Subcategories to be regulated or excluded are found in Section 6. The discussion in that section identifies and describes the pollutants to be regulated and presents the rationale for subcategory and pollutant exclusion. Section 7 describes the appropriate treatment and control technologies available. The regulatory limits and the bases for these limitations are presented in Section 8. Section 9 estimates the capital and operating costs for the treatment technologies used as the basis for limitations.

1.2 SOURCES OF INDUSTRY DATA

Data on the two subcategories were gathered from literature studies, contacts with EPA regional offices, from plant surveys and evaluations, and through contacting waste treatment equipment manufacturers. These data sources are discussed below.

*For reasons outlined in section 3.2, EPA has determined that the Electron Tube subcategory should be divided into Cathode Ray Tubes (CRT), and Receiving and Transmitting Tubes (RTT) subcategories. RTT operations do not discharge wastewaters, thus this document proposes effluent limits only for CRT and Luminescent Materials subcategories.

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Published literature in the form of books, reports, papers, periodicals, promotional materials, Dunn and Bradstreet surveys, and Department of Commerce Statistics was examined. The researched material included product descriptions and uses, manufacturing processes, raw materials consumed, waste treatment technology, and the general characteristics of plants in the two subcategories including number of plants, employment levels, and production levels when available.

All 10 EPA regional offices were telephoned for assistance in identifying plants in their respective regions.

Three types of data collection were used to supplement available information pertaining to facilities in the E&EC category. First, more than 150 plants were contacted by phone or letter to obtain basic information regarding products, manufacturing processes, wastewater generation, and waste treatment. Second, based on this information, eleven plants were visited to view their operations and discuss their products, manufacturing processes, water use, and wastewater treatment. Third, six plants were selected for sampling visits to determine the pollutant characteristics of their wastewater.

The sampling program at each plant consisted of up to three days of sampling. Prior to any sampling visit, all available data, such as layouts and diagrams of the selected plant's production processes and waste treatment facilities, were reviewed. In most cases, a visit to the plant was made prior to the actual sampling visit to finalize the sampling approach.

Representative sample points were then selected. Finally, before the visit was conducted, a detailed sampling plan showing the selected sample points and all pertinent sample data to be obtained was presented and reviewed.

Various manufacturers of wastewater treatment equipment were contacted by phone or were visited to obtain cost and performance data on specific technologies. Information collected was based both on manufacturers' research and on actual operation.

SECTION 2

LEGAL BACKGROUND

2.1 PURPOSE AND AUTHORITY

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," Section 101(a). Section 301(b)(1)(A) set a deadline of July 1, 1977, for existing industrial dischargers to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT). Section 301(b)(2)(A) set a deadline of July 1, 1983, for these dischargers to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT), which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants."

Section 306 required that new industrial direct dischargers comply with new source performance standards (NSPS), based on best available demonstrated technology. Sections 307(b) and (c) of the Act required pretreatment standards for new and existing dischargers to publicly owned treatment works (POTW). While the requirements for direct dischargers were to be incorporated into National Pollutants Discharge Elimination System (NPDES) permits issued under Section 402, the Act made pretreatment standards enforceable directly against dischargers to POTWs (indirect dischargers).

Section 402(a)(1) of the 1972 Act does allow requirements to be set case-by-case. However, Congress intended control requirements to be based, for the most part, on regulations promulgated by the Administrator of EPA. Section 304(b) required regulations for NSPS. Sections 304(f), 307(b), and 307(c) required regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants.

Finally, Section 501(a) authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

The EPA was unable to promulgate many of these regulations by the deadlines contained in the Act, and as a result, in 1976, EPA was sued by several environmental groups. In settling this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the Court. This agreement required EPA to develop a program and meet a schedule for controlling 65 "priority" pollutants and classes of pollutants. In carrying out this program, EPA must promulgate BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 21 major industries. (See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979)).

Several of the basic elements of the Settlement Agreement program were incorporated into the Clean Water Act of 1977. This law made several important changes in the Federal Water pollution control program. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now set July 1, 1984, as the deadline for industries to achieve effluent limitations requiring application of BAT for "toxic" pollutants. "Toxic" pollutants here included the 65 "priority" pollutants and classes of pollutants that Congress declared "toxic" under Section 307(a) of the Act.

EPA's programs for new source performance standards and pretreatment standards are now aimed principally at controlling toxic pollutants. To strengthen the toxics control program, Section 304(e) of the Act authorizes the Administrator to prescribe "best management practices" (BMPs). These BMPs are to prevent the release of toxic and hazardous pollutants from: (1) plant site runoff, (2) spillage or leaks, (3) sludge or waste disposal, and (4) drainage from raw material storage if any of these events are associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revises the control program for non-toxic pollutants. For "conventional" pollutants identified under Section 304(a)(4) (including biochemical oxygen demand, suspended solids, fecal coliform, and pH), the new Section 301(b)(2)(E) requires "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT)--instead of BAT--to be achieved by July 1, 1984. The factors considered in assessing BCT for an industry include the relationship between the cost of attaining a reduction in effluents and the effluent reduction benefits attained, and a comparison of the cost and level of reduction of such pollutants by publicly owned treatment works and industrial sources. For those pollutants that are neither "toxic" pollutants nor "conventional" pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987.

The purpose of this proposed regulation is to establish BPT, BAT, and BCT effluent limitations and NSPS, PSES, and PSNS for the Electrical and Electronic Components Point Source Category.

2.2 GENERAL CRITERIA FOR EFFLUENT LIMITATIONS

2.2.1 BPT Effluent Limitations

The factors considered in defining best practicable control technology currently available (BPT) include: (1) the total cost of applying the technology relative to the effluent reductions that result, (2) the age of equipment and facilities involved, (3) the processes used, (4) engineering aspects of the control technology, (5) process changes, (6) non-water quality environmental impacts (including energy requirements), (7) and other factors as the Administrator considers appropriate. In general, the BPT level represents the average of the best existing performances of plants within the industry of various ages, sizes, processes, or other common characteristics. When existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. BPT focuses on end-of-process treatment rather than process changes or internal controls, except when these technologies are common industry practice.

The cost/benefit inquiry for BPT is a limited balancing, committed to EPA's discretion, which does not require the Agency to quantify benefits in monetary terms. See, e.g., American Iron and Steel Institute v. EPA, 526 F.2d 1027 (3rd Cir. 1975). In balancing costs against the benefits of effluent reduction, EPA considers the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the cost and economic impacts of the required level of pollution control. The Act does not require or permit consideration of water quality problems attributable to particular point sources or water quality improvements in particular bodies of water. Therefore, EPA has not considered these factors. See Weyerhaeuser Company v. Costle, 590 F.2d 1011 (D.C. Cir. 1978); Applachian Power Company et al. v. U.S.E.P.A. (D.C. Cir., Feb. 8, 1972).

2.2.2 BAT Effluent Limitations

The factors considered in defining best available technology economically achievable (BAT) include the age of equipment and facilities involved, the processes used, process changes, and engineering aspects of the technology process changes, non-water quality environmental impacts (including energy requirements) and the costs of applying such technology JJ(Section 304(b)(2)(B)KK. At a minimum, the BAT level represents the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. As with BPT, uniformly inadequate performance within a category or subcategory may require transfer of BAT from a different subcategory or category. Unlike BPT, however, BAT may include process changes or internal controls, even when these technologies are not common industry practice.

The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits (see *Weyerhaeuser* v. *Costle*, *supra*). In developing the proposed BAT, however, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels. Despite this expanded consideration of costs, the primary factor for determining BAT is the effluent reduction capability of the control technology. The Clean Water Act of 1977 establishes the achievement of BAT as the principal national means of controlling toxic water pollution from direct discharging plants.

2.2.3 BCT Effluent Limitations

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(a)(4) JJbiological oxygen demanding pollutants (BOD), total suspended solids (TSS), fecal coliform, and pHKK, and any additional pollutants defined by the Administrator as "conventional" JJoil and grease, 44 FR 44501, July 30, 1979KK.

BCT is not an additional limitation but replaces BAT for the control of conventional pollutants. In addition to other factors specified in Section 304(b)(4)(B), the Act requires that BCT limitations be assessed in light of a two-part "cost reasonableness" test. *American Paper Institute* v. *EPA*, 660 F.2d 954 (4th Cir. 1981). The first test compares the costs for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

2.2.4 New Source Performance Standards

The basis for new source performance standards (NSPS) under Section 306 of the Act is the best available demonstrated technology. New plants have the opportunity to design the best and most efficient processes and wastewater treatment technologies. Therefore, Congress directed EPA to consider the best demonstrated process changes, in-plant controls, and end-of-process treatment technologies that reduce pollution to the maximum extent feasible.

2.2.5 Pretreatment Standards for Existing Sources

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for existing sources (PSES) which industry must achieve within three years ot promulgation. PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs.

The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based, analogous to the best available technology for removal of toxic pollutants. The General Pretreatment Regulations which serve as the framework for the proposed pretreatment standards are in 40 CRF Part 403, 46 FR 9404 (January 28, 1981).

EPA has generally determined that there is passthrough of pollutants if the percent of pollutants removed by a welloperated POTW achieving secondary treatment is less than the percent removed by the BAT model treatment system. A study of 40 well-operated POTWs with biological treatment and meeting secondary treatment criteria showed that metals are typically removed at rates varying from 20 percent to 70 percent. POTWs with only primary treatment have even lower rates of removal. In contrast, BAT level treatment by the industrial facility can achieve removal in the area of 97 percent or more. Thus, it is evident that metals do pass through POTWs. As for toxic organics, data from the same POTWs illustrate a wide range of removal, from 0 to greater than 99 percent. Overall, POTWs have removal rates of toxic organics which are less effective than BAT.

2.2.6 Pretreatment Standards for New Sources

Section 307(c) of the Act requires EPA to promulgate pretreatment standards for new sources (PSNS) at the same time that it promulgates NSPS. These standards are intended to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with a POTW. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies--including process changes, in-plant controls, and end-of-process treatment technologies--and to select plant sites that ensure the treatment system will be adequately installed. Therefore, the Agency sets PSNS after considering the same criteria considered for NSPS. PSNS will have environmental benefits similar to those from NSPS.

SECTION 3

INDUSTRY SUBCATEGORIZATION

3.1 RATIONALE FOR SUBCATEGORIZATION

The primary purpose of industrial categorization is to provide groupings within an industry so that each group has a uniform set of discharge limitations. After the Agency has obtained wastewater data and process information from facilities within an industry or industrial segment, a number of factors are considered to determine if subcategorization is appropriate. These factors include raw materials, final products, manufacturing processes, geographical location, plant size and age, wastewater characteristics, non-water quality environmental impacts, treatment costs, energy costs, and solid waste generation.

3.2 SUBCATEGORIZATION REVIEW

A preliminary review of each of these factors revealed that product type is the principal factor affecting the wastewater characteristics in the Electrical and Electronic Components industrial category. This is demonstrated by a comparison of pollutants found in plant effluent with the products made at those plants. Luminescent Materials (Phosphorescent Coatings) and Electron Tubes were identified as two of the twenty-one (21) subcategories comprising the E&EC category.

Under this study, further review of the same factors revealed that the Electron Tube subcategory is comprised of two distinct product types employing different raw materials and manufacturing processes. The products included in the Electron Tube subcategory are cathode ray tubes, receiving tubes and transmitting tubes. The production of receiving and transmitting tubes uses similar raw materials and manufacturing processes and thus similar wastewaters are generated. Cathode ray tube manufacture, however, employs unique raw materials and process operations which generate wastes greatly different from those encountered in the manufacture of receiving and transmitting tubes.

3.3 CONCLUSIONS

Based on the review of subcategorization factors, the following subcategories were established under this study and are addressed as such in this document.

Cathode Ray Tubes

Receiving and Transmitting Tubes

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SECTION 4

DESCRIPTION OF THE INDUSTRY

This section provides a general description of the subcategories presented in the previous section. It includes a discussion of the number of plants and production capacity, product lines, and manufacturing processes including raw materials used.

4.1 CATHODE RAY TUBES

The Cathode Ray Tube subcategory includes plants which discharge wastewater from the production of electronic devices in which high velocity electrons are focused through a vacuum to generate an image on a luminescent (or phosphorescent) surface. Products are classified under the Standard Industrial Classification (SIC) 3671 the Cathode Ray Tube (CRT) subcategory's products are comprised of two CRT types:

- Aperture Mask Tubes which are cathode ray tubes that contain multiple color phosphors and use an aperture (shadow) mask. This type of tube will be referred to as a color television picture tube.
- Cathode ray tubes that contain a single phosphor and no aperture mask. This type of tube will be referred to as a single phosphor tube.

4.1.1 Number of Plants and Production Capacity

Results of an extensive telephone survey to companies classified under SIC Code 3671 indicated that an estimated 22 plants are involved in the manufacturing of cathode ray tubes

Seven plants produce color television picture tubes with a total production of approximately 12.5 million tubes per year and an average plant production of 1.78 million tubes per year. It is estimated that 12,000 production employees are engaged in color television picture tube manufacturing. Only one of the seven manufacturers is a direct discharger. In addition, several rebuilders of color television picture tubes exist, but because there is no phosphor removal or reapplication, the rebuilding process is of little concern under this study.

Fifteen plants manufacture single phosphor tubes with an estimated 3,000 employees engaged in production. No single phosphor tube manufacturers are known to be direct dischargers.

4.1.2 Product Description

Cathode ray tubes are devices in which electrons are conducted between electrodes through a vacuum within a gas tight glass

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envelope. Cathode ray tubes depend upon three basic phenomena for their operation. The first is the emission of electrons by certain elements and compounds when the energy of the surface atoms is raised. The second phenomenon is the control of the movement of these electrons by the force exerted upon them by electrostatic and electrodynamic forces. The third is the luminescent properties of the phosphors when excited by electrons. The two types of cathode ray tubes which are to be discussed in this section are described below:

- Color television picture tubes function by the horizontal scanning of high velocity electrons striking a luminescent surface. The number of electrons in the stream at any instant of time is varied by electrical impulses corresponding to the transmitteed signal. A typical color television picture tube is shown in Figure 4-1.

  The tube is a large glass envelope. A special composition of glass is used to minimize optical defects and to provide electrical insulation for high voltages. The structural design of the glass bulb is made to withstand 3 to 6 times the force of atmospheric pressure. The light-emitting screen is made up of small elemental areas, each capable of emitting light in one of the three primary colors (red, green, blue). An electron gun for each color produces a stream of high velocity electrons which is aimed and focused by static and dynamic convergence mechanisms and an electro-magnetic deflection yoke. An aperture mask behind the face of the screen allows phosphor excitation according to incident beam direction. Commercially available color television tubes are manufactured in a number of sizes. These tubes are used in color television sets, arcade games, and computer display terminals.

- Single phosphor tubes are similar to color television picture tubes in most respects. They generate images by focusing electrons onto a luminescent screen in a pattern controlled by the electrostatic and electrodynamic forces applied to the tube. The major difference is that the light emitting screen is composed of a single phosphor, and a single beam electron gun is used for phosphor excitation. In addition, the tube does not contain an aperture mask for electron beam control.

  Single phosphor tubes are manufactured in a variety of sizes but are generally smaller in size than color television picture tubes. They usually range from 2 to 12 inches in diameter. Single phosphor tubes are manufactured for usage in display systems such as word

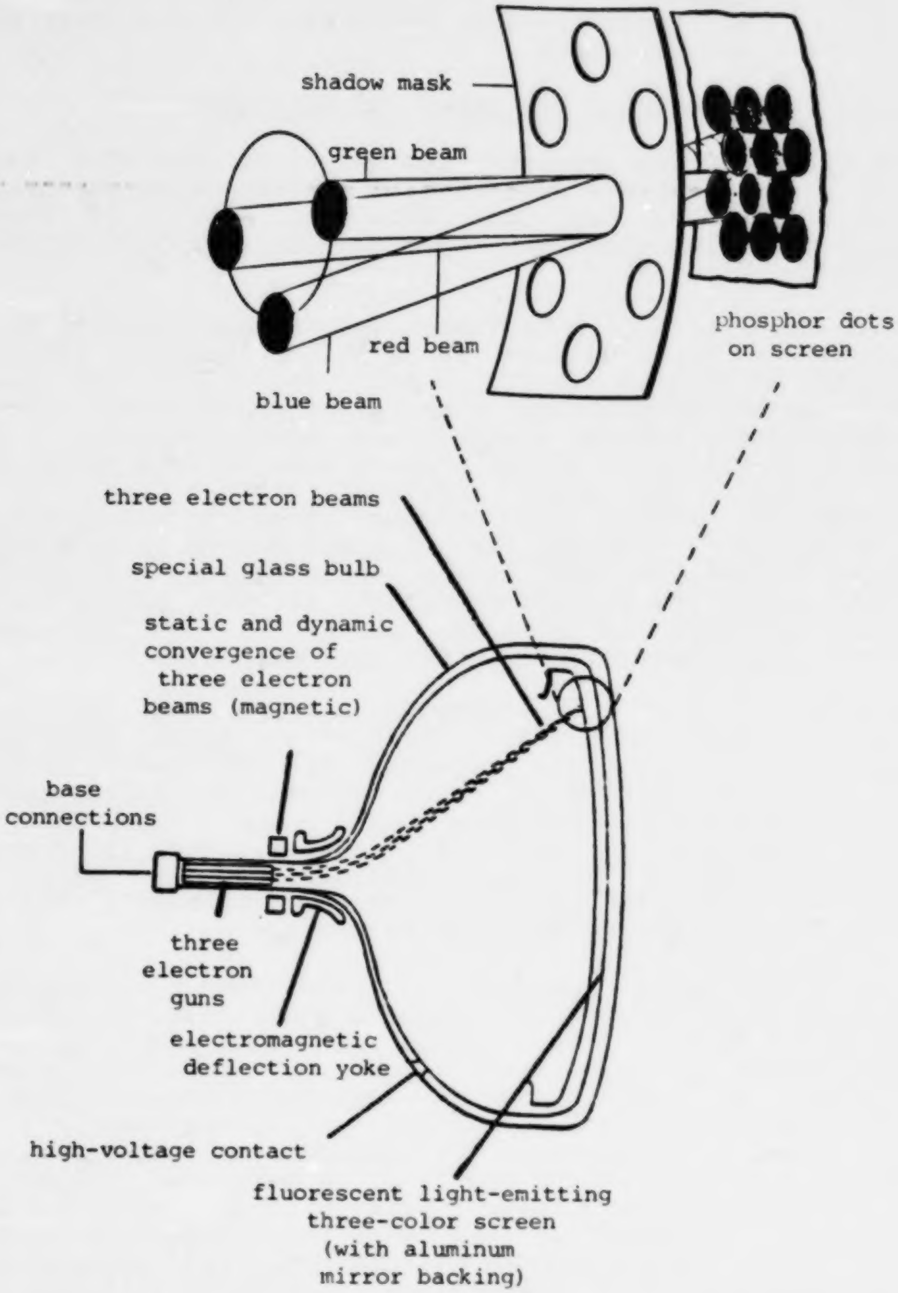
shadow mask
green beam
red beam
blue beam
phosphor dots on screen
three electron beams
special glass bulb
static and dynamic convergence of three electron beams (magnetic)
base connections
three electron guns
electromagnetic deflection yoke
high-voltage contact
fluorescent light-emitting three-color screen (with aluminum mirror backing)

FIGURE 4- 1

COLOR TELEVISION PICTURE TUBE

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processors, computer systems, arcade video games, specialized military units, medical and other electronic testing and monitoring equipment such as oscilloscopes.

4.1.3 Manufacturing Processes and Materials

The manufacturing processes and materials used for cathode ray tube production are described in the following paragraphs. Each type of cathode ray tube with its associated manufacturing operations is discussed separately because production processes differ.

Color Television Picture Tubes -- The manufacture of a color television picture tube is a highly complex, often automated process as depicted in Figure 4-2. The tubes are composed of four major components: the glass panel, steel aperture mask, glass funnel, and the electron gun mount assembly. The glass panel is the front of the picture tube through which the picture is viewed. The steel aperture (shadow) mask is used to selectively shadow the phosphor from the electron beam as the beam horizontally scans the phosphor-coated glass panel. The glass funnel is the casing which extends back from the glass panel and is the largest component of the picture tube. The mount assembly is attached to the funnel and contains the electron gun and the electrical base connections.

Manufacture of a color television picture tube begins with an aperture mask degrease. The aperture masks, often produced at other facilities, are received by the color picture tube manufacturer, formed to size, solvent degreased, and oxidized. Common degreasing solvents used are methylene chloride, trichloroethylene, methanol, acetone, and isopropanol. The aperture masks are inserted within the glass panel which is commonly then referred to as a panel-mask "mate". The panel-mask mate is annealed and the mask is removed.

The glass panels proceed to panel wash. Panel wash includes several hydrofluoric-sulfuric acid glass washes and subsequent water rinses. The panels are then sent to photoresist application. The photoresist commonly contains dichromate, an alcohol, and other materials considered proprietary. The glass panels are coated with a photoresist and the masks are mated to the panel. The panel is then exposed to light through the mask. The mask is removed and the panel is developed, graphite-coated, re-developed and cleaned with a hydrofluoric-sulfuric acid solution. The panel at this point has a multitude of clear dots onto which the phosphors will be deposited. Presently, several manufacturers are using vertical lines as an alternative to dots. The panels then proceed to phosphor application.

Many proprietary processes have been observed in applying the phosphors. Generally, the panels first undergo another

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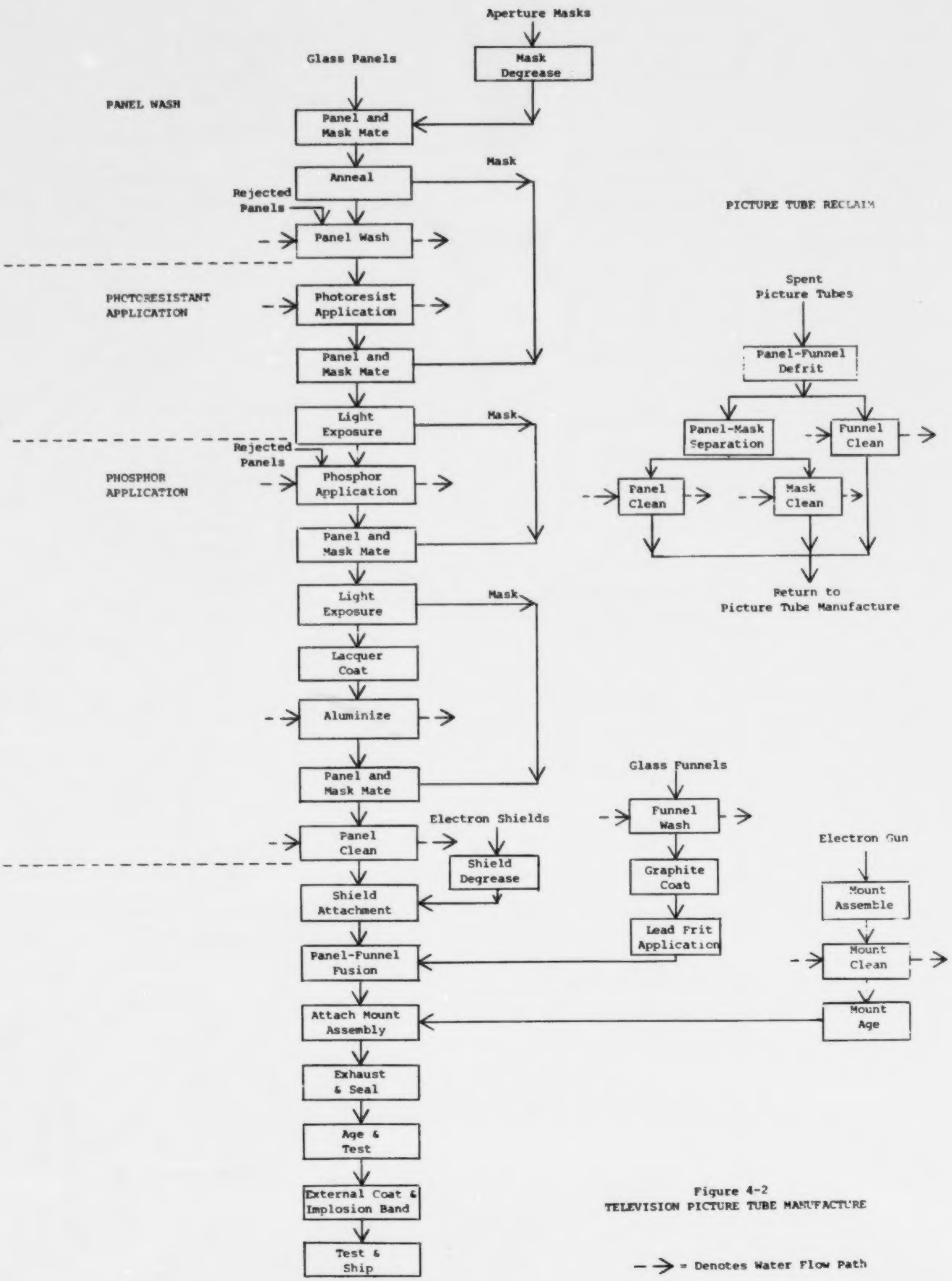

Figure 4-2
TELEVISION PICTURE TUBE MANUFACTURE

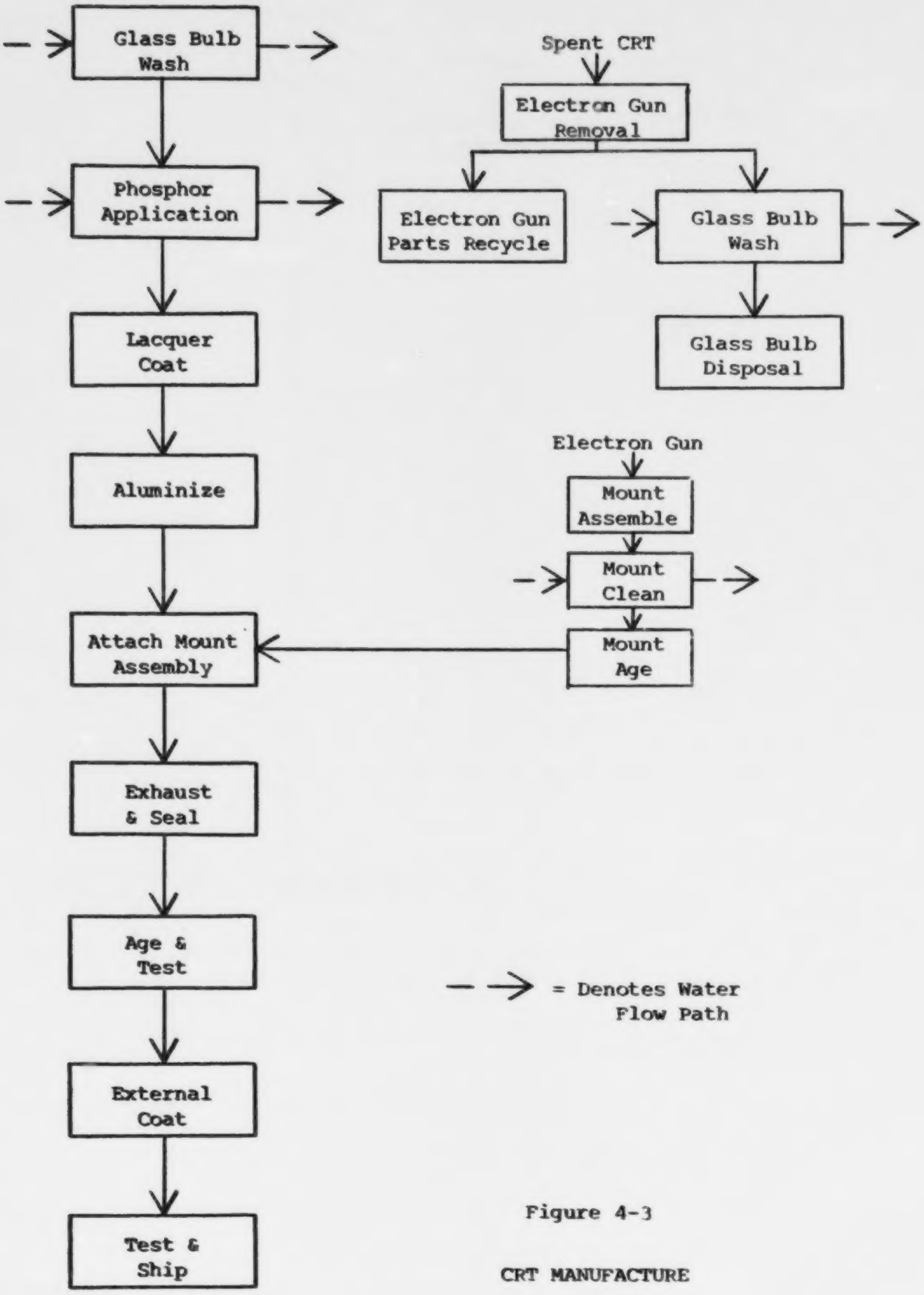

Figure 4-3

CRT MANUFACTURE

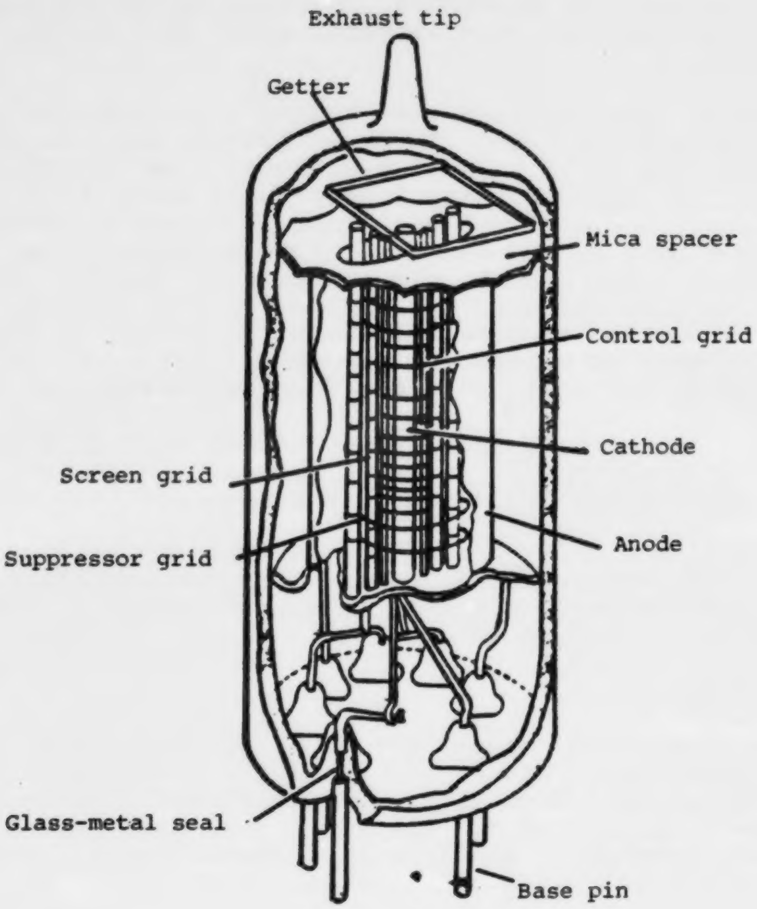

FIGURE 4-4

RECEIVING TUBE

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photoresist application. Each of the three color phosphors is then applied similarly. The phosphor is applied to the panel as a slurry or as a powder, the mask is attached, the phosphor is exposed to light through the mask, the mask is removed and the unexposed phosphor is washed away. After application of the three phosphors, toluene-based lacquer and silicate coatings may be applied to seal the phosphors, aluminum is vacuum-deposited to enhance reflection, the mask is mated with the panel, and the panel is cleaned.

Glass funnels are cleaned and coated with graphite to prevent reflection within the tube. Electron shields are degreased and attached to the panel. Panel-mask assemblies and glass funnels are then joined together using a heat-fused lead frit, followed by annealing. The electron gun mount is cleaned, aged, and heat sealed to the base of the funnel. At this stage the assembled panel, funnel, and mount are termed a "bulb." The bulb is exhausted, sealed, and aged by applying current to the cathode. The tube is tested, an external graphite coating is applied, and an implosion band is secured to the tube. The tube is retested before shipment to facilities that assemble television sets.

Panels may be rejected upon inspection at many points along the manufacturing process. If rejected, panels may be sent back to the panel wash at the beginning of the manufacturing sequence.

In addition, there is a picture tube salvage operation to reclaim spent or rejected picture tubes. Salvage operation processes include a panel-funnel acid defrit, acid cleaning of panels and funnels, and cleaning of aperture masks. These reclaimed components are returned to the process for reuse. Electron guns are usually discarded.

Wastewater producing operations for manufacture of television picture tubes are unique and sizeable. Process wastewater sources include both bath dumps and subsequent rinsing associated with: glass panel wash, aperture mask degrease, photoresist application, phosphor application, glass funnel and mount cleaning, and tube salvage.

Single Phosphor Tubes -- Single phosphor tubes have several manufacturing processes that differ from color television picture tube manufacturing (Figure 4-3). The tube is usually composed of a single glass bulb; only a small percentage of the tubes manufactured have a separate panel and funnel connected by a heat fused lead frit.

The one piece tube manufacturing requires no mask and no photoresist application. The single phosphor is contained within an aqueous settling solution that is poured into the glass bulb and allowed to settle onto the face of the bulb. After a sufficient time the remaining settling solution is decanted off and a toluene-based lacquer is applied to seal the phosphor.

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In some cases where the bulb face needs a special application, such as reference lines for an oscilloscope, a separate panel and funnel are used. A photoresist and mask are used for applying the reference lines on the panel and then the single phosphor is applied in the same method as a one piece bulb using a settling solution that contains potassium silicate and usually an electrolyte.

In addition, there may or may not be a cathode ray tube salvage operation. The tube salvage is usually comprised of the removal of the electron gun by cutting the tube at the gun mount and recycling parts of the gun. The remaining glass tube is then discarded. At some facilities the tube is washed to remove the phosphor before disposal.

The decant from the settling solution and the wash from phosphor removal are usually the main sources of wastewater in single phosphor tube manufacturing.

4.2 RECEIVING AND TRANSMITTING TUBES

The Receiving and Transmitting Tube subcategory includes electronic devices in which conduction of electrons takes place through a vacuum or a gaseous medium within a sealed glass, quartz, metal or ceramic casing. Products are classified under the Standard Industrial Classifications (SIC) 3671, 3673.

4.2.1 Number of Plants and Production Capacity

Results of an extensive telephone survey to companies classified under the above SIC Codes indicated that an estimated 23 major plants are involved in the manufacturing of receiving and transmitting tubes with an estimated 10,000 employees engaged in production. Several small receiving and transmitting tube manufacturers probably exist.

4.2.2 Product Description

Receiving and transmitting tubes conduct electrons or ions between electrodes through a vacuum or ionized gas such as neon, argon or krypton, which is within a gas-tight casing of glass, quartz, ceramic, or metal. Their operation is based on the emission of electrons by certain elements and compounds when the energy of the surface atoms is raised by the addition of heat, light protons, kinetic energy of bombarding particles, or potential energy. The operation also depends on the control of the movement of these electrons by the force exerted upon them by electric and magnetic fields.

- Receiving tubes are multiterminal devices that conduct electricity more easily in one direction than in the other and are noted for their low voltage and low power applications (Figure 4-4). They are used to control or amplify electrical signals in radio and television receivers, computers, and sensitive control and measuring equipment.

Structurally, electron tubes are classified according to the number of electrodes they contain. The electrodes are usually made of nickel mounted on a base penetrated by electrical connections and are encapsulated in a glass or metal envelope which is normally evacuated.

Voltage is impressed on the tube normally between the plate (anode) and the cathode. Because large plate currents are not required for electron emission, oxide-coated cathodes are used extensively. A separate filament heats the cathode which usually consists of a nickel sleeve coated with oxides such as strontium oxide or barium oxide. There is no electrical connection between the cathode and filament causing the cathode to be heated indirectly.

- Transmitting type electron tubes are characterized by the use of electrostatic and electromagnetic fields applied externally to a stream of electrons to amplify a radio frequency signal. There are several different types of transmitting tubes such as klystrons, magnetrons and traveling wave tubes. They generally are high powered devices operating over a wide frequency range. They are larger and structurally more rugged than receiving tubes, and are completely evacuated. Figure 4-5 is a diagram of a klystron tube, which is typical of a transmitting type tube. In a klystron tube, a stream of electrons from a concave thermionic cathode is focused into a small cylindrical beam by the converging electrostatic fields between the anode, cathode, and focusing electrode. The beam passes through a hole in the anode and enters a magnetic field parallel to the beam axis. The magnetic field holds the beam together, overcoming the electro-static repulsion between electrons. The electron beam goes through the cavities of the klystron, emerges from the magnetic field, spreads out and is stopped in a hollow collector where the remaining kinetic energy of the electrons is dissipated as heat.

4.2.3 Manufacturing Processes and Materials

The manufacture of a receiving tube is similar to that of a transmitting tube and is depicted schematically in Figure 4-6. Raw materials required for receiving tube manufacture include glass envelopes, kovar and other specialty metals, tungsten wire, and copper wire. The metal parts are punched and formed, chemically cleaned, and electroplated with copper, nickel, chromium, gold, or silver. The iron or nickel cathode is coated with a getter solution which will be used to absorb gases. The metal parts are hand assembled into a tube mount assembly. Glass parts for the tube base are cut and heat treated. Copper connector pins are sealed in the "glass mount" machine. The glass mount piece is then heat treated by baking in an oven. The metal tube mount assembly is then hand welded to the glass mount piece. The upper glass bulb is rinsed. On a "sealex" machine, the bulb is evacuated to 10ZQ-3 mm of mercury, sealed, and the glass extensions are cut off. A getter material (usually magnesium, calcium, sodium, or phosphorus) previously introduced in the evacuated envelope is flashed. Flashing occurs by applying an electric current to the electrodes of the tube for several seconds or by indirect infrared radiation. The getter material condenses on the inside surface and absorbs (reacts with) any gas molecules. The result is that the vacuum within the tube becomes progressively stronger until an equilibrium value of 10ZQ-6 mm is reached. The glass exterior is rinsed and the completed tube is aged, tested, and packaged.

The manufacture of a typical transmitting tube is presented schematically in Figure 4-7. Intricately shaped and machined copper, steel, and ceramic parts are cleaned and rinsed. Some of these parts are then electroplated using materials such as copper, gold, and silver. Assembly of the electron tube is generally a manual operation. The electron tube components consist of the above-described parts, a tungsten filament, a glass window, and a glass tube. The components undergo a number of soldering, brazing, welding, heat treating, and polishing operations. A significant energy user is the heat treating area with associated non-contact cooling water. The assembled electron tube undergoes an extensive series of electrical and mechanical testing procedures and an aging process before final shipment. There are specialized types of transmitting type electron tubes, such as image intensifiers, that are produced in a manner similar to that described above. However, there are two wet processes utilized in addition to those depicted in Figure 4-7. These additional wet processes include alkaline cleaning/rinsing and alcohol dipping/rinsing of ceramic or glass envelopes brazed to metal; and acid cleaning of glass tube bodies. Because these processes are known to exist at only one facility, they are not included in Figure 4-7 as processes common to most transmitting type electron tube manufacture.

Process water is used in solutions and rinses associated with electroplating of anodes, cathodes, and grids. Water is also used to wash glass and ceramic tube bodies both before and after seating to the base, or at the conclusion of the manufacturing process.

Receiving and transmitting electron tube manufacturing processes produce wastewater discharges primarily through metal finishing operations which are covered under the Metal Finishing Category. A number of ancillary operations such as deionized water backwash, cooling tower blowdown, and boiler blowdown contribute sizeable wastewater discharges compared to metal finishing operations.

In addition, there are some isolated instances of plants manufacturing specialized transmitting type electron tubes such as image intensifiers and photomultipliers that require process water. Alkaline cleaning and acid etching of glass-metal and ceramic tube components discharge process wastewater as a result of alkaline and acid bath dumps and their associated water rinses. These wet processes are similar to several found in color television picture tube manufacture. There is also a glass tube rinse (or rinses) which concludes the manufacture of receiving tubes. Such rinses are intended to remove surface particulates and dust deposited on the tube body during the manufacturing process.

4.3 LUMINESCENT MATERIALS

Luminescent materials (phosphors) are those that emit electromagnetic radiation (light) upon excitation by such energy sources as photons, electrons, applied voltage, chemical reactions, or mechanical energy. These luminescent materials are used for a variety of applications, including fluorescent lamps, high-pressure mercury vapor lamps, color television picture tubes and single phosphor tubes, lasers, instrument panels, postage stamps, laundry whiteners, and specialty paints.

This study is restricted to those materials which are applicable to the E&EC category, specifically to those used as coatings in fluorescent lamps and color television picture tubes and single phosphor tubes.

4.3.1 Number of Plants

A telephone survey of the industry determined that only five facilities manufacture luminescent materials, and according to industry personnel, two of these facilities are the major producers.

Of the five luminescent materials manufacturers, one manufactures TV phosphors only; three manufacture both lamp and TV phosphors; and one manufacture only lamp phosphors. At three facilities wastewater flow from the phosphor operations amount to less than twenty percent of the total plant flow. Of the five facilities, one has no discharge, two discharge to a POTW and the remaining two discharge to surface water.

4.3.2 Product Description

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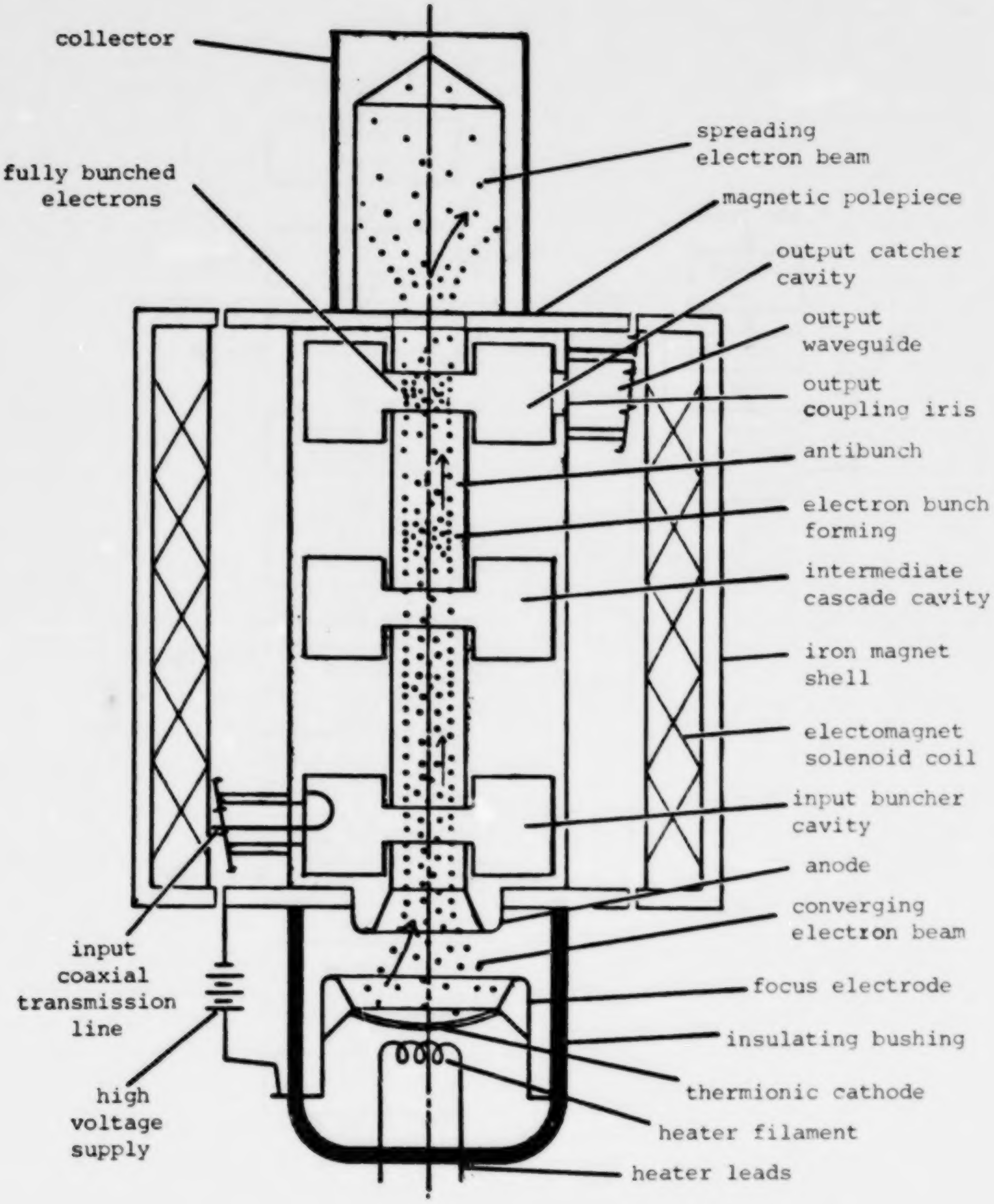

FIGURE 4-5

TRANSMITTING TUBE

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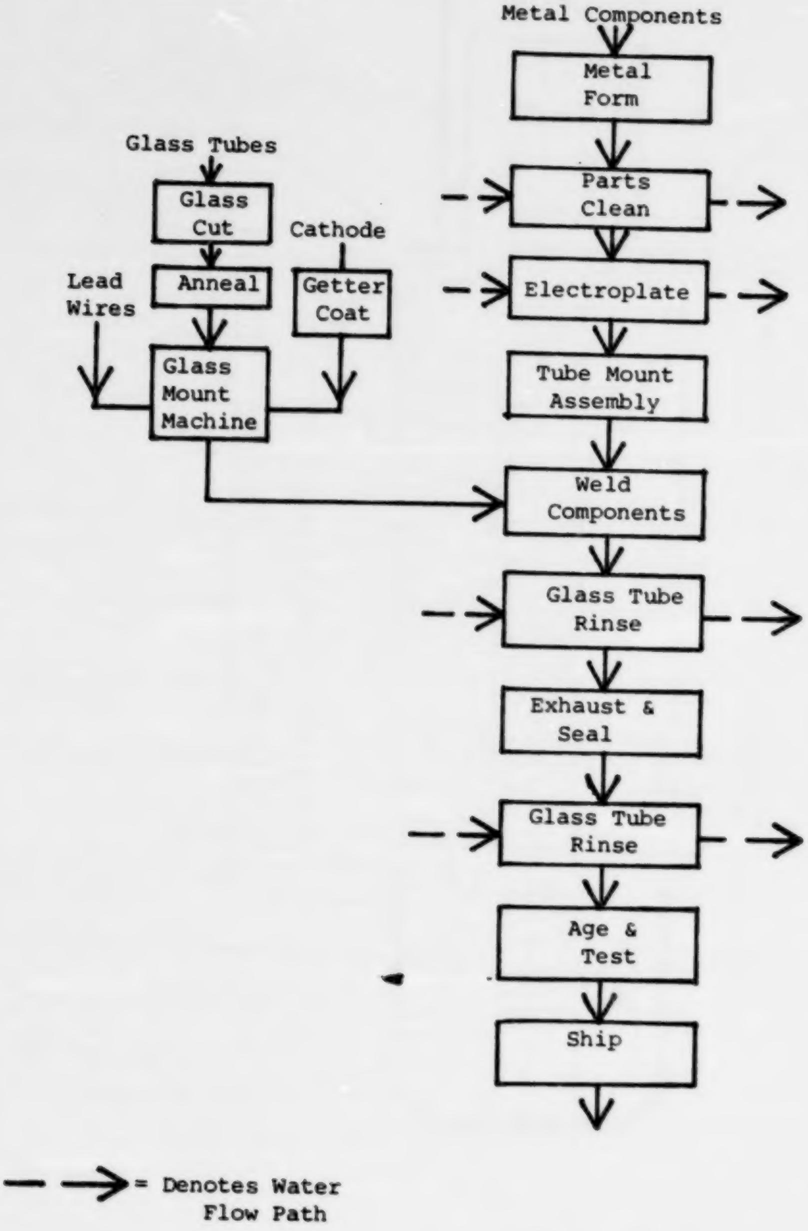

FIGURE 4- 6

RECEIVING TUBE MANUFACTURE

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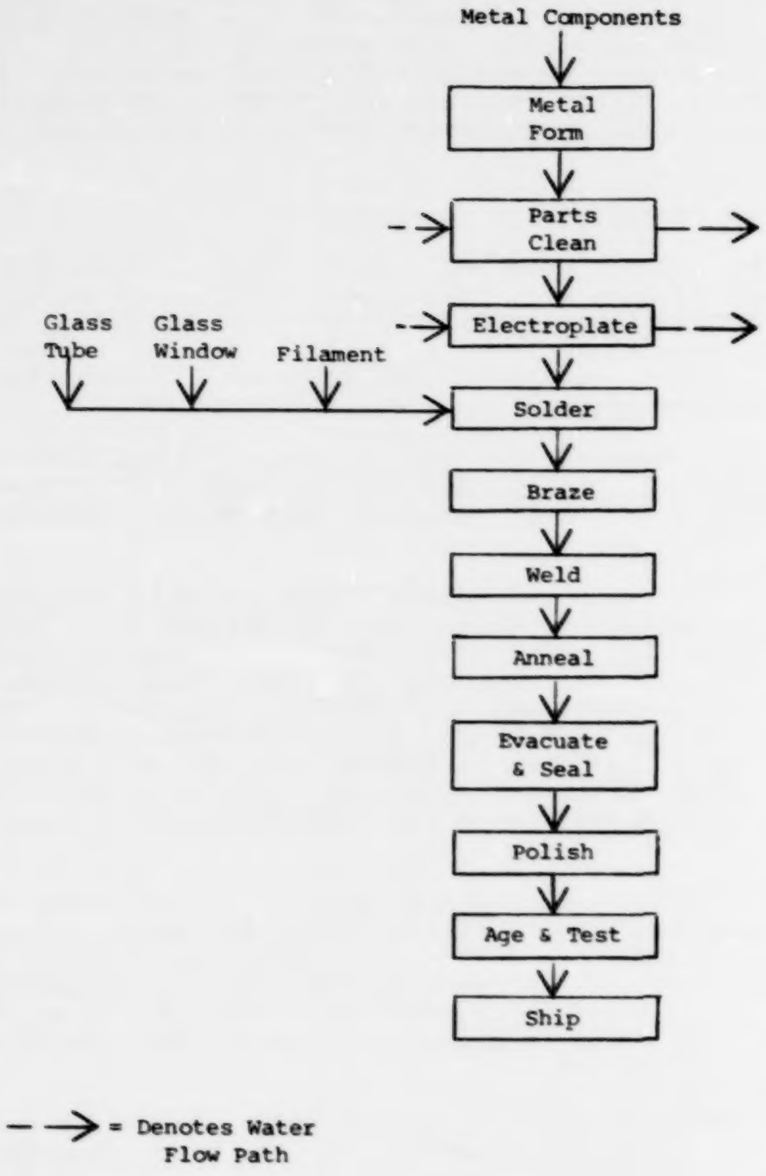

Figure 4-7

TRANSMITTING TUBE MANUFACTURE

The most important fluorescent lamp phosphor is calcium halophosphate. There are at least 50 types of phosphors used for cathode ray tubes (television and other video displays). However, all are similar to or mixes of the three major color television powders: red, blue, and green. The red phosphor is yttrium oxide activated with europium; the blue phosphor is zinc sulfide activated with silver, and the green phosphor is zinc-cadmium sulfide activated with copper. The major process steps in producing luminescent materials are reacting, milling, and firing the raw material; recrystallizing raw materials, if necessary; and washing, filter-ing, and drying the intermediate and final products. The products are then sold and shipped as powders.

4.3.3 Manufacturing Processes and Materials

Lamp phosphors and TV phosphors with their associated manufacturing operations are discussed separately because production processes and raw materials differ. The processes and materials described were taken from a typical plant; however, some variations occur between manufacturers. Proprietary compounds used in process operations are not identified.

Lamp Phosphors -- Preparation of calcium halophosphate, $Ca_5(F,Cl)(PO_4)_3$ involves the production of two intermediate powders and the firing of the combined intermediate powders (Figure 4-8).

Calcium phosphate intermediate powder is produced by reacting calcium salts with anions. These raw materials are first purified and filter pressed separately. The two streams are then combined to precipitate the soluble calcium. This resultant material, CaCQ3 ZQ. $CaHPO_4$, is subsequently filtered and recrystallized in heated deionized water for particle size assurance. The material is then filtered and dried. Liquid waste originates from washing, filtration (precipitation), wet scrubber blowdown, and filtration of the recrystallized process stream.

Calcium fluoride (CaF_2) intermediate powder is produced by reacting calcium hydroxide with nitric acid to make calcium nitrate solution. This is mixed with ammonium bifluoride crystals dissolved in water, to precipitate calcium fluoride. Calcium fluoride is washed by decantation, filtered and dried. Liquid wastes originate from washing, filtering and scrubber blowdown.

The intermediate powders are milled together, blended, fired, washed, filtered and dried to produce calcium halo phosphate phosphor.

TV Phosphors -- There are three primary TV phosphors currently being manufactured: red, blue and green. The manufacturing of both blue and green phosphors requires a two-stage process that involves the production of an intermediate material and then its activation and firing. The manufacturing of red phosphor is a solid state reaction.

Figure 4-9 is a process flow diagram for the production of blue phosphor, which is primarily a zinc sulfide phosphor activated with silver (ZnS:Ag). The intermediate material is produced by dissolving zinc oxide in sulfuric acid. The zinc sulfate solution is reacted with hydrogen sulfide gas to precipitate zinc sulfide out of solution. The product is washed, vacuum filtered and dried. The intermediate powder is blended with the activator (usually silver), fired, washed, filtered and dried. Liquid wastes originate from precipitation, washing, filtration, and scrubber blowdown.

The green phosphor is produced from zinc-cadmium sulfide that is activated with copper (Zn(Cd)S:Cu). The intermediate material is produced by dissolving cadmium oxide in sulfuric acid and deionized water to produce a cadmium sulfate solution. Sulfide gas and zinc sulfide that was produced in the same method as described in the blue phosphor, are introduced to the solution. The precipitate is washed several times and then dried to produce the cadmium-zinc sullfide intermediate powder. The intermediate powder is mixed with the activator copper, and fired. The material is washed, vacuum filtered, and dried to produce the final product zinc-cadmium phosphor. Liquid wastes originate from precipitation, washing, filtration, and scrubber blowdown.

The red phosphor is a rare earth phosphor manufactured from yttrium oxide that is activated with europium (Y_2O_3:Eu(III)). The production is a solid state reaction in which yttrium oxide, europium oxide and certain salts are blended, fired, washed, and dried to produce the final red phosphor. Liquid waste originates from washing and scrubber blowdown.

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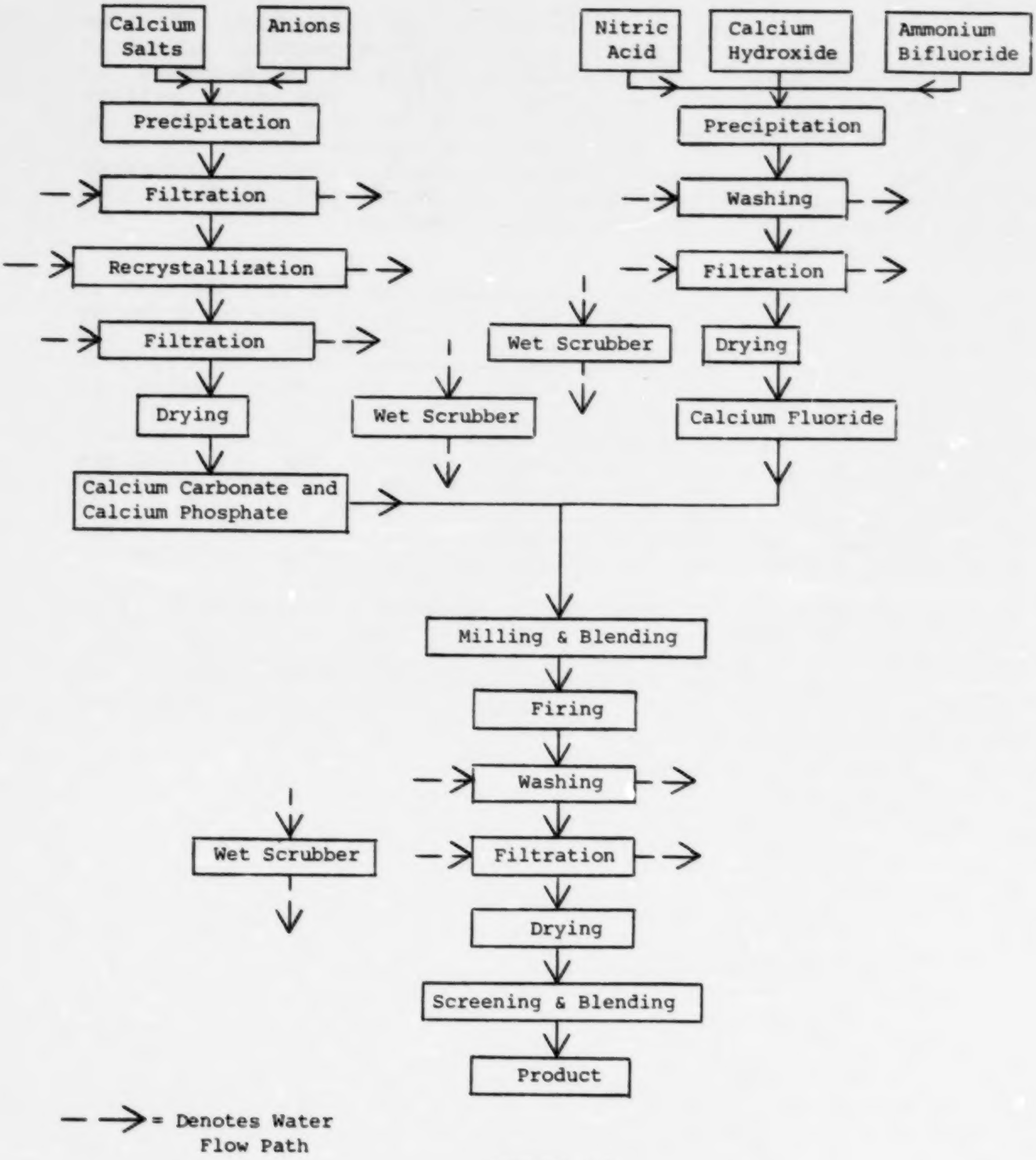

FIGURE 4-8

LAMP PHOSPHOR PROCESS

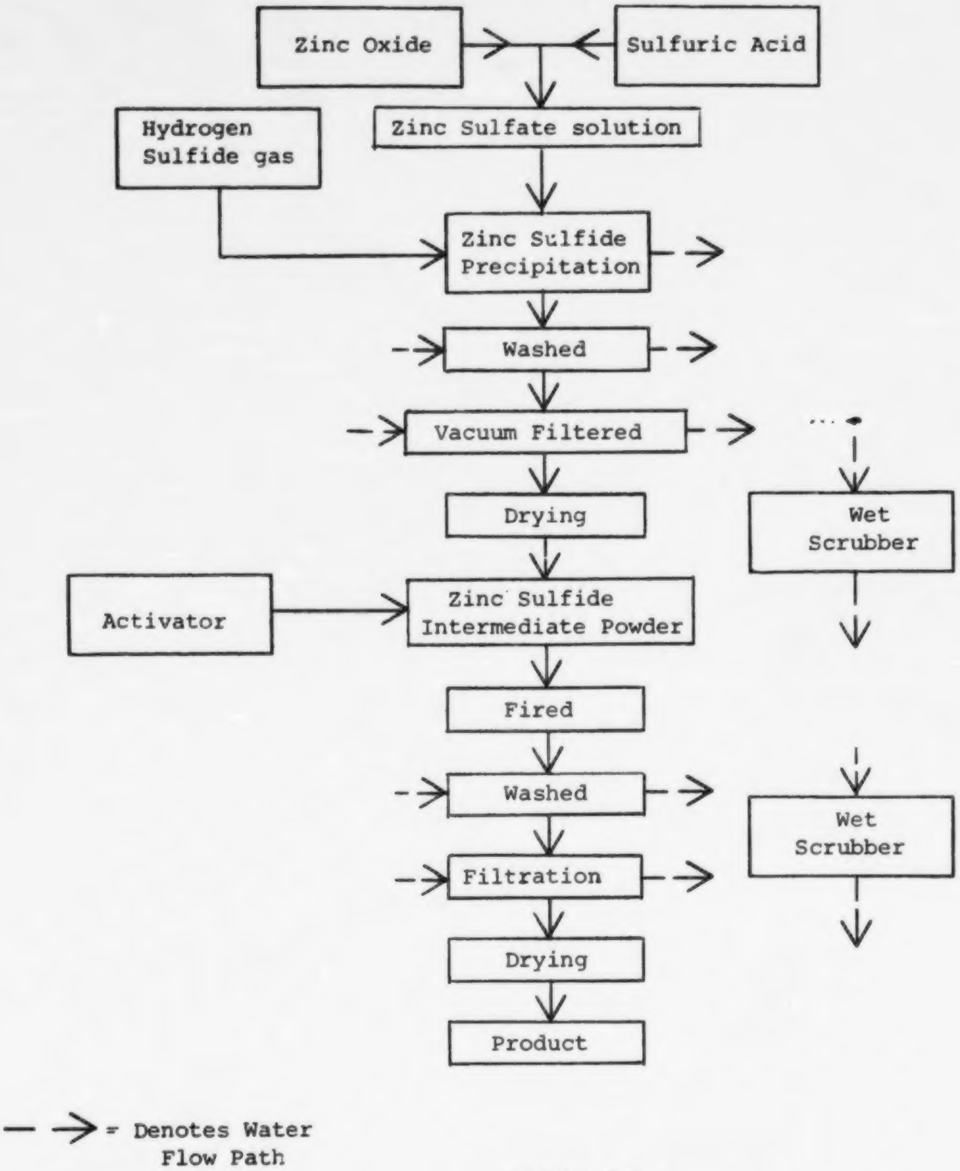

FIGURE 4-9

BLUE PHOSPHOR PROCESS

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SECTION 5

WASTEWATER CHARACTERISTICS

This section presents information related to wastewater flows, wastewater sources, pollutants found, and the sources of these pollutants for Cathode Ray Tube, Receiving and Transmitting Tube, and Luminescent Materials subcategories. A general discussion of sampling techniques and wastewater analysis is also provided.

5.1 SAMPLING AND ANALYTICAL PROGRAM

More than 150 plants were contacted to obtain information on the three subcategories. Eleven of these plants were visited for an on-site study of their manufacturing processes, water used and wastewater treatment. In addition, wastewater samples were collected at six of the plants visited in order to quantify the level of pollutants in raw process wastewater and treatment effluent.

5.1.1 Pollutants Analyzed

The chemical pollutants sought in analytical procedures fall into three groups: conventional, non-conventional, and toxics. The latter group comprises the 129 chemicals found in the toxic pollutant list shown in Table 5-1.

Conventional pollutants are those generally treatable by secondary municipal wastewater treatment. The conventional pollutants examined for this study are:

pH
Biochemical Oxygen Demand (BOD)
Oil and Grease (O&G)
Total Suspended Solids (TSS)

Non-conventional pollutants are simply those which are neither conventional nor on the list of toxic pollutants. The non-conventional pollutants listed below were examined during this study.

Fluoride
Total Organic Carbon
Total Phenols
Yttrium
Calcium
Magnesium
Aluminum
Sodium
Titanium
Palladium
Tellurium
Manganese
Vanadium
Boron
Barium
Molybdenum
Tin
Cobalt
Iron
Platinum
Gold

TABLE 5-1
TOXIC POLLUTANTS

TOXIC POLLUTANT ORGANICS

1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Benzene
5. Benzidine
6. Carbon Tetrachloride (Tetrachloromethane)
7. Chlorobenzene
8. 1,2,4-Trichlorobenzene
9. Hexachlorobenzene
10. 1,2-Dichloroethane
11. 1,1,1-Trichloroethane
12. Hexachloroethane
13. 1,1-Dichloroethane
14. 1,1,2-Trichloroethane
15. 1,1,2,2-Tetrachloroethane
16. Chloroethane
17. Bis(Chloromethyl)Ether
18. Bis(2-Chloroethyl)Ether
19. 2-Chloroethyl Vinyl Ether (Mixed)
20. 2-Chloronaphthalene
21. 2,4,6-Trichlorophenol
22. Parachlorometa Cresol
23. Chloroform (Trichloromethane)
24. 2-Chlorophenol
25. 1,2-Dichlorobenzene
26. 1,3-Dichlorobenzene
27. 1,4-Dichlorobenzene
28. 3,3'-Dichlorobenzidine
29. 1,1-Dichloroethylene
30. 1,2-Trans-Dichloroethylene
31. 2,4-Dichlorophenol
32. 1,2-Dichloropropane
33. 1,2-Dichloropropylene (1,3-Dichloropropene)
34. 2,4-Dimethylphenol
35. 2,4-Dinitrotoluene
36. 2,6-Dinitrotoluene
37. 1,2-Diphenylhydrazine
38. Ethylbenzene
39. Fluoranthene
40. 4-Chlorophenyl Phenyl Ether
41. 4-Bromophenyl Phenyl Ether
42. Bis(2-Chloroisopropyl) Ether
43. Bis(2-Chloroethoxy)Methane
44. Methylene Chloride
45. Methyl Chloride (Chloromethane)
46. Methyl Bromide (Bromomethane)
47. Bromoform (Tribromomethane)
48. Dichlorobromoethane
49. Trichlorofluoromethane
50. Dichlorodifluoromethane
51. Chlorodibromomethane
52. Hexachlorobutadiene
53. Hexachlorocyclopentadiene
54. Isophorone
55. Naphthalene
56. Nitrobenzene
57. 2-Nitrophenol
58. 4-Nitrophenol
59. 2,4-Dinitrophenol
60. 4,6-Dinitro-O-Cresol
61. N-Nitrosodimethylamine
62. N-Nitrosodiphenylamine
63. N-Nitrosodi-N-Propylamine
64. Pentachlorophenol
65. Phenol
66. Bis(2-ethylhexyl)Phthalate
67. Butyl Benzyl Phthalate
68. Di-N-Butyl Phthalate
69. Di-N-Octyl Phthalate
70. Diethyl Phthalate
71. Dimethyl Phthalate
72. 1,2-Benzanthracene (Benzo(A)Anthracene)
73. Benzo (A) Pyrene (3,4-Benzo-Pyrene)
74. 3,4-Benzofluoranthene (Benzo(B) (Fluoranthene)
75. 11,12-Benzofluoranthene (Benzo(K) Fluoranthene)
76. Chrysene
77. Acenaphthylene
78. Anthracene
79. 1,12-Benzoperylene(Benzo(GHI)-Perylene)
80. Fluorene
81. Phenanthrene
82. 1,2,5,6-Dibenzathracene(Dibenzo(A,H) Anthracene)
83. Ideno(1,2,3-CD)Pyrene(2,3-0-Phenylene Pyrene)
84. Pyrene
85. Tetrachloroethylene
86. Toluene
87. Trichloroethylene
88. Vinyl Chloride (Chloroethylene)
89. Aldrin
90. Dieldrin

TABLE 5-1- continued

91. Chlordane (Technical Mixture and Metabolites)
92. 4,4'-DDT
93. 4,4'-DDE (P,P'-DDX)
94. 4,4'-DDD (P,P-TDE)
95. Alpha-Endolsufan
96. Beta-Endosulfan
97. Endosulfan Sulfate
98. Endrin
99. Endrin Aldehyde
100. Heptachlor
101. Heptachlor Epoxide (BHC-Hexachlorocyclohexane)
102. Alpha-BHC
103. Beta-BHC
104. Gamma-BHC
105. Delta-BHC
106. PCB-1242 (Arochlor 1242)
107. PCB-1254 (Arochlor 1254)
108. PCB-1221 (Arochlor 1221)
109. PCB-1232 (Arochlor 1232)
110. PCB-1248 (Arochlor 1248)
111. PCB-1260 (Arochlor 1260)
112. PCB-1016 (Arochlor 1016)
113. Toxaphene
114. Antimony
115. Arsenic
116. Asbestos
117. Beryllium
118. Cadmium
119. Chromium
120. Copper
121. Cyanide
122. Lead
123. Mercury
124. Nickel
125. Selenium
126. Silver
127. Thallium
128. Zinc
129. 2,3,4,8-Tetrachlorodibenzo-P-Dioxin (TCDD)

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5.1.2 Sampling Methodology

During the initial visit to a facility, a selection was made of sampling points so as to best characterize process wastes and evaluate the efficiency of any wastewater treatment. The nature of the wastewater flow at each selected sampling point then determined the method of sampling, i.e., automatic composite or grab composite. The sampling points were of individual raw waste streams, or treated effluent.

Each sample was collected whenever possible by an automatic time series compositor over a single 24-hour sampling period. When automatic compositing was not possible, grab samples were taken at intervals over the same period, and were composited manually. When a sample was taken for analysis of toxic organics, a blank was also taken to determine the level of contamination inherent to the sampling and transportation procedures.

Each sample was divided into several portions and preserved, when necessary, in accordance with established procedures for the measurement of toxic and classical pollutants. Samples were shipped in ice-cooled containers by the best available route to EPA-contracted laboratories for analysis. Chain of custody for the samples was maintained through the EPA Sample Control Center tracking forms.

5.1.3 Analytical Methods

The analytical techniques for the identification and quantitation of toxic pollutants were those described in Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants, revised in April 1977.

In the laboratory, samples for organic pollutant analysis were separated by specific extraction procedures into acid (A), base/neutral (B/N), and pesticide (P) fractions. Volatile organic samples (V) were taken separately as a series of grab samples at four-hour intervals and composited in the laboratory. The analysis of these fractions incorporated the application of strict quality control techniques including the use of standards, blanks, and spikes. Gas chromatography and gas chromatography/mass spectrometry were the analytical procedures used for the organic pollutants. Two other analytical methods were used for the measurement of toxic metals: flameless atomic absorption and inductively coupled argon plasma spectrometric analysis (ICAP). The metals determined by each method were:

Flameless AA	ICAP
Antimony	Beryllium
Arsenic	Cadmium
Selenium	Chromium
Silver	Copper

Thallium

Lead
Nickel
Zinc

Mercury was analyzed by a special manual cold-vapor atomic absorption technique.

For the analysis of conventional and non-conventional pollutants, procedures described by EPA were followed. The following conventions were used in quantifying the levels determined by analysis:

- Pollutants detected at levels below the quantitation limit are reported as "less than" (XZ) the quantitation limit. All other pollutants are reported as the measured value.
- The tables show data for total toxic organics, toxic and non-toxic metals, and other pollutants. Total toxic organics is the sum of all toxic organics found at concentrations of 0.01 mg/l or greater.
- Blank Entries - Entries were left blank when the parameter was not detected.

5.2 CATHODE RAY TUBES

5.2.1 Wastewater Flow

Presented below is a summary of the quantities of wastewater generated by the manufacturers of color television picture tubes and other single phosphor tubes.

	Wastewater Discharge (gpd)		
Number of Plants	Min.	Mean	Max.
22	XZ50	135,500	500,000

5.2.2 Wastewater Sources

Process wastewater sources from the manufacture of cathode ray tubes are sizeable and include wash and rinse operations associated with: glass panel wash, mask degrease, photoresist application, phosphor application, glass funnel and mount cleaning, and tube salvage.

5.2.3 Pollutants Found and the Sources of These Pollutants

The major pollutants of concern from the Cathode Ray Tube subcategory are:

pH

Chromium

TABLE 5-2

CATHODE RAY TUBE
SUMMARY OF RAW WASTE DATA

	CONCENTRATION, mg/l		
PARAMETER	MINIMUM	MAXIMUM	MEAN
TOXIC METALS			
114 Antimony	0.036	0.196	0.097
115 Arsenic	0.149	0.284	0.207
117 Beryllium	<0.001	0.005	0.003
118 Cadmium	0.041	0.626	0.374
119 Chromium	0.800	2.149	1.314
120 Copper	0.012	0.087	0.038
122 Lead	4.04	13.00	9.41
123 Mercury	0.001	0.003	0.002
124 Nickel	0.020	0.082	0.065
125 Selenium	0.001	0.007	0.004
126 Silver	0.001	0.002	0.001
127 Thallium	0.001	0.001	0.001
128 Zinc	2.610	19.72	11.79
Total Toxic Organics*	0.030	0.150	0.085
Oil and Grease	2.158	16.0	7.72
Biochemical Oxygen Demand	0.107	17	7.38
Total Suspended Solids	21.01	380	185
Fluoride	31.7	970.8	360.6

*3 day sample of one plant

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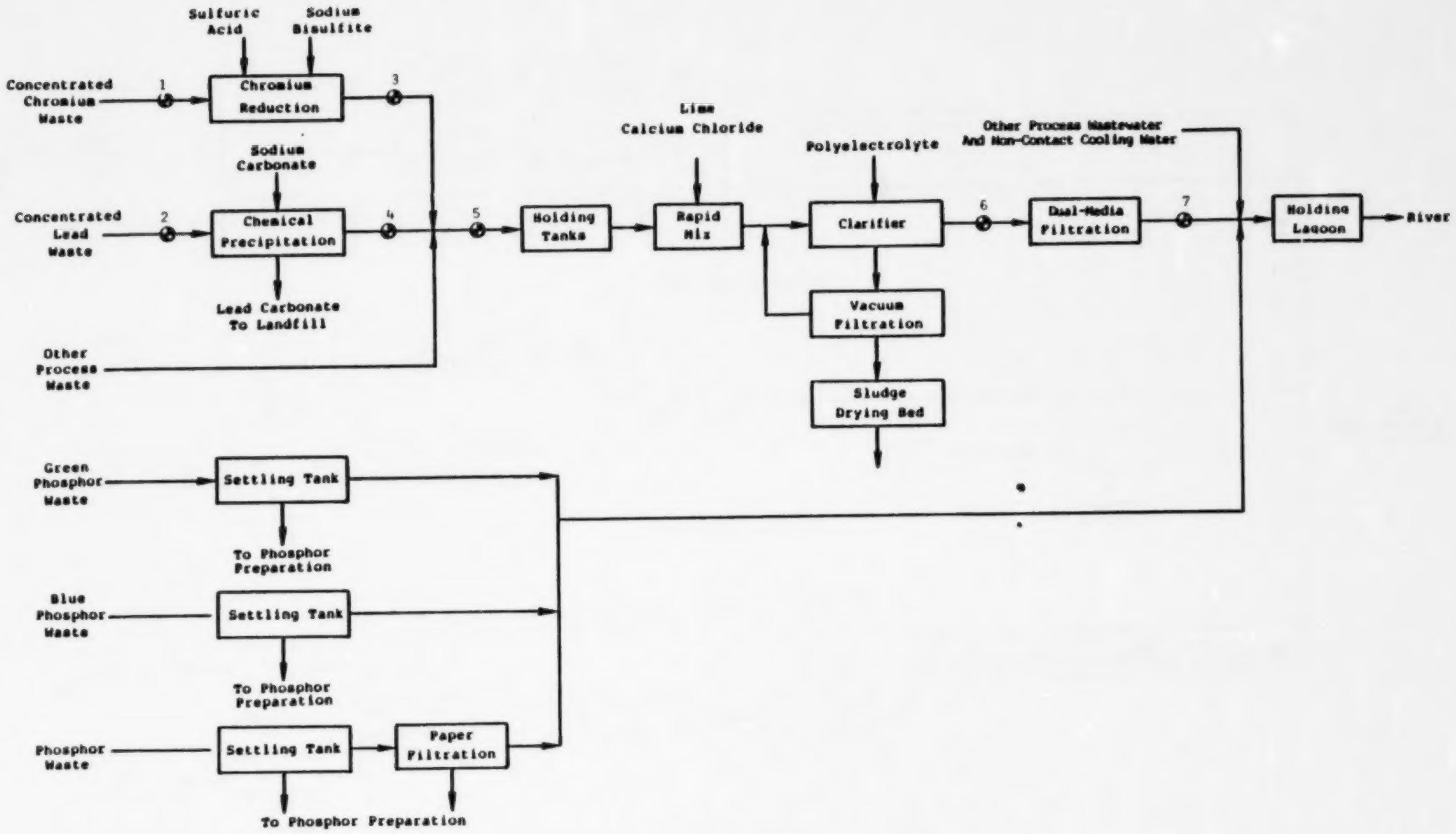

Figure 5-1

PLANT 30172 SAMPLING LOCATIONS

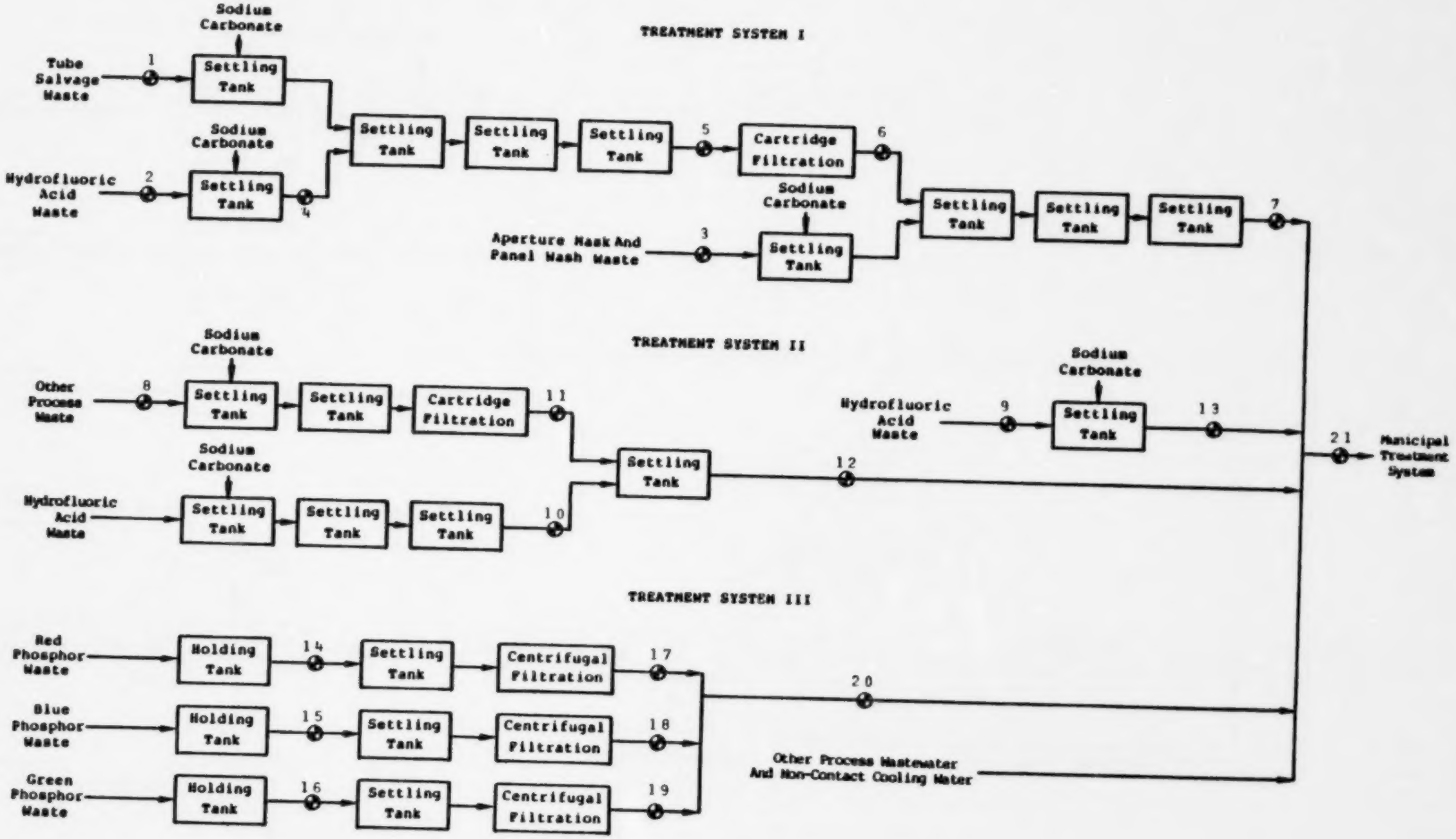

Figure 5-2

PLANT 11114 SAMPLING LOCATIONS

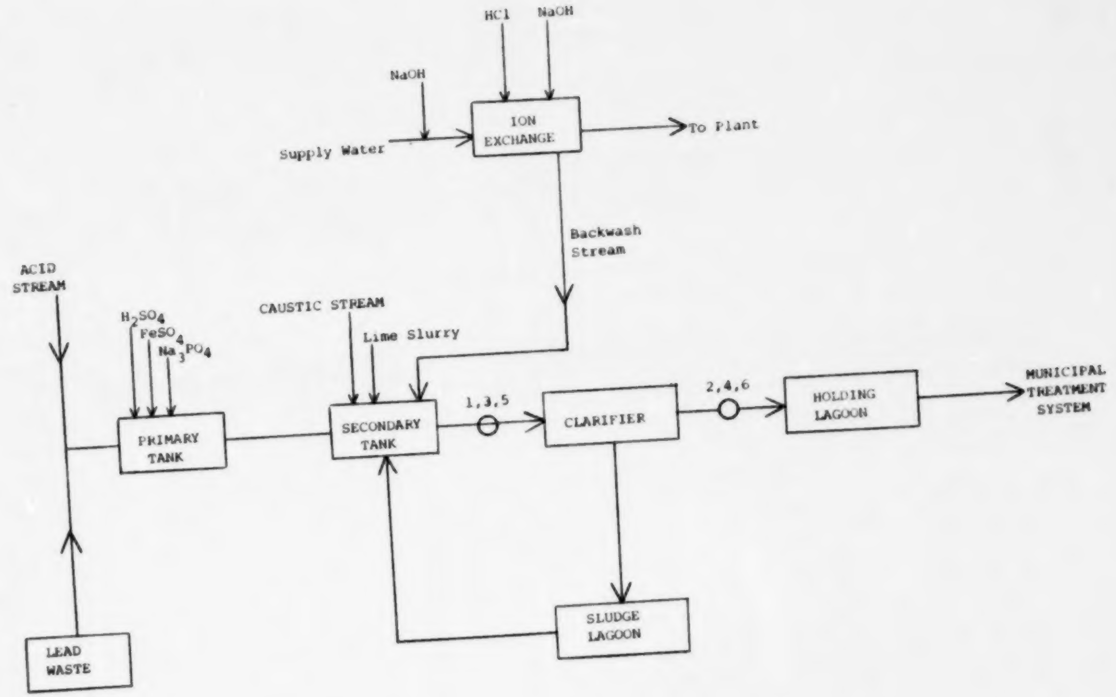

FIGURE 5-3

PLANT 99796 SAMPLING LOCATIONS

TABLE 5-3
PICTURE TUBE PROCESS WASTES
Plant 30172

Stream Identification	Chromium Reduction Influent	Lead Treatment Influent	Chromium Reduction Effluent
Sample Number	1*	2	3*
Flow Rate Liters/Hr-Gallon/day	440/2790	45/285	440/2794
Duration Hours/Day	24	24	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS		Not Analyzed	Not Analyzed
4 Benzene	<0.010		
11 1,1,1-Trichloroethane	0.058		
39 Fluoranthene	<0.010		
44 Methylene chloride	0.490		
55 Napthalene	<0.010		
66 Bis(2-ethylhexyl)phthalate	0.460		
67 Butyl benzyl phthalate	0.010		
78 Anthracene	<0.010		
81 Phenanthrene	<0.010		
84 Pyrene	<0.010		
86 Toluene	0.029		
87 Trichloroethylene	0.010		
Total Toxic Organics	1.057		
121 Cyanide	<0.005	<0.005	<0.005
TOXIC INORGANICS			
114 Antimony	0.003	0.092	0.044
115 Arsenic	0.006	0.250	0.017
117 Beryllium	0.001	0.004	<0.001
118 Cadmium	<0.002	1.070	<0.002
119 Chromium	89.07	4.670	73.33
120 Copper	0.019	<0.05	0.016
122 Lead	0.125	891.	0.062
123 Mercury	<0.001	0.001	<0.001
124 Nickel	0.006	18.5	<0.005
125 Selenium	0.004	<0.020	0.011
126 Silver	0.001	0.060	<0.001
127 Thallium	0.017	0.002	<0.001
128 Zinc	<0.013	1510.	0.02
NON-CONVENTIONAL POLLUTANTS			
Calcium	2.82	87.8	3.83
Magnesium	0.70	30.9	0.93
Sodium	8.14	640	60.1
Aluminum	0.037	12	0.039
Manganese	0.006	5.860	0.019
Vanadium	0.014	0.161	0.008
Boron	0.122	346	0.162
Barium	0.03	205	0.026
Molybdenum	0.132	1.60	0.13
Tin	0.101	3.010	0.83
Yttrium	0.042	16.8	0.147
Cobalt	0.058	2.650	0.058
Iron	0.105	1940	2.13
Titanium	0.005	0.319	<0.002
Phenols	0.013	0.01	0.013
Total Organic Carbon	706.7	<1.0	773.3
Fluoride	1.17	160	0.433
CONVENTIONAL POLLUTANTS			
pH	5.13	<2.0	3.1
Oil & Grease	33	11	121
Biochemical Oxygen Demand	8	<1.0	23.7
Total Suspended Solids	1.27	190	1.2

*Average of three samples.

TABLE 5-3
PICTURE TUBE PROCESS WASTES
Plant 30172 - continued

Stream Identification	Lead Treatment Effluent	Primary Treatment Influent
Sample Number	4**	5*
Flow Rate Liters/Hr-Gallon/day	127/268	12905/81820
Duration Hours/Day	8	24
	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
121 Cyanide	<0.005	0.005
TOXIC INORGANICS		
114 Antimony	0.069	0.153
115 Arsenic	0.009	0.121
117 Beryllium	<0.001	<0.001
118 Cadmium	<0.005	0.171
119 Chromium	0.022	2.87
120 Copper	0.042	0.066
122 Lead	0.19	14.17
123 Mercury	<0.001	<0.001
124 Nickel	0.911	0.341
125 Selenium	0.006	<0.004
126 Silver	0.002	0.0013
127 Thallium	<0.01	<0.001
128 Zinc	18.7	6.08

*Average of three samples.
**Average of two samples.

NON-CONVENTIONAL POLLUTANTS		
Calcium	29.6	82.93
Magnesium	17.3	8.32
Sodium	11950	145.33
Aluminum	0.628	3.83
Manganese	0.59	0.044
Vanadium	0.017	0.006
Boron	322.5	8.59
Barium	10.27	0.771
Molybdenum	0.214	0.064
Tin	0.249	0.056
Yttrium	<0.01	1.683
Cobalt	0.308	<0.05
Iron	0.229	8.56
Titanium	0.032	0.075
Phenols	0.045	<0.01
Total Organic Carbon	89.5	49.3
Fluoride	78.5	340
CONVENTIONAL POLLUTANTS		
pH	6.85	2.17
Oil & Grease	11	12.3
Biochemical Oxygen Demand	<1	<1
Total Suspended Solids	11	89.3

TABLE 5-3
PICTURE TUBE PROCESS WASTES
Plant 30172 - continued

Stream Identification	Primary Treatment Effluent	Filter Effluent
Sample Number	6*	7*
Flow Rate Liters/Hr-Gallon/day	12500/79252	12905/81820
Duration Hours/Day	24	24
	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
121 Cyanide	<0.005	<0.01
TOXIC INORGANICS		
114 Antimony	0.117	0.120
115 Arsenic	0.009	0.009
117 Beryllium	<0.001	<0.001
118 Cadmium	<0.002	<0.002
119 Chromium	0.244	0.208
120 Copper	0.015	0.014
122 Lead	0.253	0.163
123 Mercury	<0.001	<0.001
124 Nickel	0.013	0.015
125 Selenium	<0.005	<0.004
126 Silver	<0.001	<0.001
127 Thallium	<0.001	<0.001
128 Zinc	0.131	0.075
NON-CONVENTIONAL POLLUTANTS		
Calcium	322.5	306.3
Magnesium	7.05	7.81
Sodium	132.5	145
Aluminum	0.397	0.301
Manganese	0.007	0.007
Vanadium	0.002	<0.001
Boron	1.97	2.293
Barium	0.166	0.144
Molybdenum	0.039	<0.035
Tin	<0.025	0.07
Yttrium	0.006	<0.003
Cobalt	<0.05	<0.05
Iron	0.230	0.115
Titanium	<0.002	<0.002
Phenols	0.020	0.023
Total Organic Carbon	35.5	39.67
Fluoride	7.1	11.07
CONVENTIONAL POLLUTANTS		
pH	7.9	7.73
Oil & Grease	297.33	20.67
Biochemical Oxygen Demand	3.0	5.33
Total Suspended Solids	3.0	3.13

*Average of three samples.

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TABLE 5-4
PICTURE TUBE PROCESS WASTES.
PLANT 11114
Treatment System I

Stream Identification	Tube Salvage Waste Influent	HF - HNO_3 Tube Salvage Waste Influent	Mask Panel Waste Influent
Sample Number	1	2	3
Flow Rate Liters/Hr-Gallon/day	10674/67700	426/2700	11128/70600
Duration Hours/Day	24	Batch	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed	
4 Benzene			<0.010
23 Chloroform			<0.010
44 Methylene Chloride			<0.010
55 Nepthalene			<0.010
66 Bis(2-ethylhexyl)phthalate			0.020
67 Butyl benzyl phthalate			<0.010
68 Di-N-butyl phthalate			<0.010
86 Toluene			<0.010
87 Trichloroethylene			<0.010
95 Alpha-Endosulfan			<0.005
Total Toxic Organics			0.020
121 Cyanide	0.018	0.250	0.009
TOXIC INORGANICS			
114 Antimony	0.058	0.520	0.046
115 Arsenic	0.244	1.420	0.052
117 Beryllium	<0.005	<0.005	<0.005
118 Cadmium	0.127	13.400	0.094
119 Chromium	0.041	3.200	0.735
120 Copper	0.016	0.950	0.198
122 Lead	33.500	749.	0.516
123 Mercury	<0.001	<0.001	<0.001
124 Nickel	0.042	3.240	0.020
125 Selenium	<0.010	<0.050	<0.002
126 Silver	0.003	0.100	<0.001
127 Thallium	<0.001	0.002	<0.001
128 Zinc	9.080	1430.	1.170
NON-CONVENTIONAL POLLUTANTS			
Calcium	30.70	116.	19.60
Magnesium	12.10	46.7	4.850
Sodium	495.	3040.	35.70
Aluminum	9.920	62.3	9.150
Manganese	0.006	0.863	0.012
Vanadium	<0.001	0.074	0.005
Boron	11.70	280.	11.50
Barium	0.524	54.0	0.397
Molybdenum	<0.035	0.173	<0.035
Tin	<0.025	0.329	<0.025
Yttrium	1.030	23.7	0.590
Cobalt	<0.050	0.491	<0.050
Iron	1.880	0.264	1.280
Titanium	0.046	0.567	0.127
Phenols	0.005	0	0.027
Total Organic Carbon	35	94	139
Fluoride	780	2700	1923
CONVENTIONAL POLLUTANTS			
pH	5.6		2.7
Oil & Grease	38	20	1
Biochemical Oxygen Demand	0	0	0
Total Suspended Solids	127	68	185

TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System I - continued

Stream Identification	HF - HNO_3 Tube Salvage Post Settle	Pre-Filtration
Sample Number	4	5
Flow Rate Liters/Hr-Gallon/day	473/3000	11147/70700
Duration Hours/Day	Batch	24
	mg/l	mg/l
TOXIC ORGANICS		Not Analyzed
4 Benzene	<0.010	
23 Chloroform	<0.010	
44 Methylene Chloride	0.010	
55 Nepthalene	<0.010	
66 Bis(2-ethylhexyl)phthalate	0.130	
67 Butyl benzyl phthalate	0.010	
68 Di-N-butyl phthalate	<0.010	
86 Toluene	<0.010	
87 Trichloroethylene	<0.010	
Total Toxic Organics	0.150	
121 Cyanide	0.185	0.011
TOXIC INORGANICS		
114 Antimony	0.335	0.055
115 Arsenic	0.088	0.078
117 Beryllium	<0.005	<0.005
118 Cadmium	1.150	0.206
119 Chromium	0.024	0.035
120 Copper	0.066	0.030
122 Lead	2.010	12.000
123 Mercury	0.001	<0.001
124 Nickel	0.858	0.076
125 Selenium	<0.010	<0.010
126 Silver	0.004	0.001
127 Thallium	<0.010	<0.001
128 Zinc	47.800	18.800
NON-CONVENTIONAL POLLUTANTS		
Calcium	0.792	8.260
Magnesium	2.310	8.300
Sodium	13100.	1170.
Aluminum	17.3	7.070
Manganese	0.248	0.023
Vanadium	0.018	<0.002
Boron	155.	21.20
Barium	1.90	0.289
Molybdenum	0.092	<0.036
Tin	0.071	<0.026
Yttrium	0.043	0.358
Cobalt	0.602	<0.051
Iron	0.923	1.600
Titanium	0.139	0.037
Phenols	0.026	0
Total Organic Carbon	187	7
Fluoride	6950	910
CONVENTIONAL POLLUTANTS		
pH		6.2
Oil & Grease	25	20
Biochemical Oxygen Demand	0	12
Total Suspended Solids	75	39

TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System I - continued

Stream Identification	Post Filtration	Final Effluent
Sample Number	6	7
Flow Rate Liters/Hr-Gallon/day	11147/70700	22275/141000
Duration Hours/Day	24	24
	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
121 Cyanide	0.185	0.525
TOXIC INORGANICS		
114 Antimony	0.046	0.061
115 Arsenic	0.156	0.064
116 Beryllium	0.005	<0.005
118 Cadmium	0.201	0.370
119 Chromium	0.027	0.305
120 Copper	0.015	0.030
122 Lead	6.640	13.800
123 Mercury	<0.001	<0.001
124 Nickel	0.074	0.111
125 Selenium	0.010	<0.002
126 Silver	<0.001	0.002
127 Thallium	<0.001	<0.001
128 Zinc	18.100	32.800
NON-CONVENTIONAL POLLUTANTS		
Calcium	4.420	8.310
Magnesium	6.800	7.730
Sodium	1180.	1200.
Aluminum	6.790	7.610
Manganese	0.024	0.048
Vanadium	<0.001	<0.001
Boron	18.00	19.40
Barium	0.163	0.503
Molybdenum	<0.035	<0.035
Tin	<0.025	<0.025
Yttrium	0.053	0.049
Cobalt	<0.050	<0.050
Iron	1.120	2.040
Titanium	0.032	0.122
Phenols	0	0.034
Total Organic Carbon	4	89
Fluoride	1070	1140
CONVENTIONAL POLLUTANTS		
pH	6.0	6.1
Oil & Grease	20	51
Biochemical Oxygen Demand	22	0
Total Suspended Solids	22	80

TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System II

Stream Identification	Other Process Waste Influent	HF - Dump	HF Etch Settle Effluent
Sample Number	8	9	10
Flow Rate Liters/Hr-Gallon/day	17033/108000	142/900	20439/86400
Duration Hours/Day	24	Batch	16
	mg/l	mg/l	mg/l
TOXIC ORGANICS		Not Analyzed	Not Analyzed
4 Benzene	<0.010		
29 1,1-Dichloroethylene	<0.010		
38 Ethylbenzene	<0.010		
44 Methylene chloride	0.020		
66 Bis(2-ethylhexyl)phthalate	0.010		
68 Di-N-butyl phthalate	<0.010		
86 Toluene	<0.010		
87 Trichloroethylene	0.030		
Total Toxic Organics	0.060		
121 Cyanide	Not Analyzed	0.011	
TOXIC INORGANICS			
114 Antimony	0.440	27.000	0.003
115 Arsenic	0.266	9.000	0.005
117 Beryllium	<0.005	<0.010	<0.005
118 Cadmium	0.076	0.975	<0.005
119 Chromium	0.025	1.500	5.580
120 Copper	0.013	0.074	0.127
122 Lead	2.570	6.820	<0.050
123 Mercury	<0.001	0.002	<0.001
124 Nickel	0.014	0.420	0.144
125 Selenium	<0.002	<0.300	<0.010
126 Silver	<0.001	0.001	0.001
126 Thallium	<0.001	<0.025	<0.001
128 Zinc	2.130	10.300	0.194
NON-CONVENTIONAL POLLUTANTS			
Calcium	26.20	6.220	19.70
Magnesium	8.270	2.920	7.080
Sodium	637.	5250.	786.
Aluminum	9.830	311.	0.121
Manganese	0.007	0.540	0.296
Vanadium	0.002	0.326	<0.001
Boron	17.700	862.	0.770
Barium	1.900	5.110	0.034
Molybdenum	0.074	1.840	<0.035
Tin	<0.025	0.311	<0.025
Yttrium	0.681	0.047	0.042
Cobalt	<0.050	<0.100	<0.050
Iron	1.220	22.20	80
Titanium	0.453	15.20	<0.002
Phenols	0	0.008	0
Total Organic Carbon	8	24	5
Fluoride	1800	8400	15
CONVENTIONAL POLLUTANTS			
pH	2.3		7.7
Oil & Grease	14	17	18
Biochemical Oxygen Demand	0	0	16
Total Suspended Solids	137	3350	178

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TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System II - continued

Stream Identification	Post Filtration	System II Final Effluent	HF - Dump Effluent
Sample Number	11	12	13
Flow Rate Liters/Hr-Gallon/day	17033/10800	30659/194000	170/1080
Duration Hours/Day	24	24	Batch
	mg/l	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed	
4 Benzene			<0.010
44 Methylene chloride			<0.010
66 Bis(2-ethylhexyl)phthalate			<0.010
86 Toluene			<0.010
87 Trichloroethylene			<0.010
Total Toxic Organics			<0.010
121 Cyanide		0.520	
TOXIC INORGANICS			
114 Antimony	0.440	0.079	3.200
115 Arsenic	0.191	0.062	1.570
117 Beryllium	<0.005	<0.005	<0.005
118 Cadmium	0.018	0.006	0.031
119 Chromium	0.015	3.750	0.020
120 Copper	0.016	0.100	0.020
122 Lead	0.883	0.315	3.190
123 Mercury	<0.001	<0.001	<0.001
124 Nickel	<0.013	0.097	<0.013
125 Selenium	0.004	<0.010	<0.025
126 Silver	0.002	<0.001	0.004
127 Thallium	<0.001	<0.001	<0.010
128 Zinc	0.605	0.318	1.080
NON-CONVENTIONAL POLLUTANTS			
Calcium	6.090	15.10	3.310
Magnesium	3.340	5.700	1.190
Sodium	1810.	1050.	10800.
Aluminum	9.410	5.060	62.600
Manganese	0.003	0.196	<0.001
Vanadium	0.003	0.002	0.045
Boron	17.800	11.00	193.
Barium	0.616	0.229	1.630
Molybdenum	<0.035	0.037	0.087
Tin	<0.025	<0.025	0.089
Yttrium	o.152	0.081	0.025
Cobalt	<0.051	<0.050	0.548
Iron	0.636	56.70	1.050
Titanium	0.313	0.112	0.412
Phenols	0	0	0.008
Total Organic Carbon	10	8	472
Fluoride	4000	700	4500
CONVENTIONAL POLLUTANTS			
pH	6.6	7.5	
Oil & Grease	18	10	17
Biochemical Oxygen Demand	11	0	0
Total Suspended Solids	16	135	38

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TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System III

Stream Identification	Red Phosphor Waste Influent	Blue Phosphor Waste Influent	Green Phosphor Influent
Sample Number	14	15	16
Flow Rate Liters/Hr-Gallon/day	1703/10800	1703/10800	1703/10800
Duration Hours/Day	24	24	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed	Not Analyzed
TOXIC INORGANICS			
114 Antimony	<0.001	0.001	<0.001
115 Arsenic	0.008	0.002	0.006
117 Beryllium	<0.005	<0.005	<0.005
118 Cadmium	0.120	0.756	184.
119 Chromium	3.710	4.480	4.970
120 Copper	<0.013	<0.013	0.024
122 Lead	<0.050	<0.050	<0.050
123 Mercury	<0.001	<0.001	<0.001
124 Nickel	<0.013	<0.013	<0.013
125 Selenium	<0.010	<0.010	<0.010
126 Silver	0.004	0.360	0.005
127 Thallium	<0.001	<0.001	<0.001
128 Zinc	2.860	1910	1540.
NON-CONVENTIONAL POLLUTANTS			
Calcium	0.271	5.120	0.481
Magnesium	0.496	0.794	<0.049
Sodium	149.	1280.	787.
Aluminum	0.188	1.010	0.426
Manganese	<0.001	<0.001	<0.001
Vanadium	0.172	<0.001	<0.003
Boron	0.721	<0.002	2.390
Barium	0.012	0.151	0.825
Molybdenum	0.133	<0.035	<0.069
Tin	0.591	0.111	0.123
Yttrium	1300.	8.160	0.411
Cobalt	4.730	<0.050	0.293
Iron	<0.001	0.024	0.093
Titanium	0.038	<0.002	<0.004
CONVENTIONAL POLLUTANTS			
pH	5.0	4.0	4.9
Total Suspended Solids	1840	2560	2450

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TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System III - continued

Stream Identification	Red Phosphor Effluent	Blue Phosphor Effluent	Green Phosphor Effluent
Sample Number	17	18	19
Flow Rate Liters/Hr-Gallon/day	1703/10800	1703/10800	1703/10800
Duration Hours/Day	24	24	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed	Not Analyzed
Cyanide		28	28
TOXIC INORGANICS			
114 Antimony	<0.001	<0.001	0.004
115 Arsenic	<0.002	<0.002	<0.002
117 Beryllium	<0.005	<0.005	<0.005
118 Cadmium	0.065	0.020	11.600
119 Chromium	2.620	3.750	2.380
120 Copper	<0.013	<0.013	<0.013
122 Lead	<0.050	<0.050	<0.050
123 Mercury	<0.001	<0.001	<0.001
124 Nickel	<0.013	<0.013	<0.013
125 Selenium	0.020	<0.002	<0.002
126 Silver	<0.001	0.008	0.001
127 Thallium	<0.001	<0.001	<0.001
128 Zinc	0.718	31.500	19.100
NON-CONVENTIONAL POLLUTANTS			
Calcium	0.157	1.110	0.257
Magnesium	<0.025	0.187	<0.025
Sodium	9.930	20.200	18.300
Aluminum	2.400	0.158	0.021
Manganese	<0.001	<0.001	<0.001
Vanadium	<0.001	<0.001	<0.001
Boron	0.383	0.137	0.094
Barium	0.005	0.552	0.538
Molybdenum	<0.035	<0.035	<0.035
Tin	<0.025	<0.025	<0.025
Yttrium	2.460	0.142	0.037
Cobalt	0.186	0.193	0.212
Iron	0.031	0.009	0.004
Titanium	0.007	<0.002	<0.002
CONVENTIONAL POLLUTANTS			
pH	5.0		
Total Suspended Solids	8	36	35

TABLE 5-4
PICTURE TUBE PROCESS WASTES
PLANT 11114
Treatment System III - continued

Stream Identification	Total Phosphor Effluent	Total Plant Effluent
Sample Number	20	21
Flow Rate Liters/Hr-Gallon/day	5110/32400	283875/1800000
Duration Hours/Day	24	24
	mg/l	mg/l
TOXIC ORGANICS		
4 Benzene	<0.010	<0.010
11 1,1,1-Trichloroethane	<0.010	0.050
13 1,1-Dichloroethane		<0.010
23 Chloroform	<0.010	
29 1,1-Dichloroethylene	<0.010	<0.010
30 1,2-trans-dichloroethylene		<0.010
38 Ethylbenzene	<0.010	<0.010
44 Methylene chloride	0.020	0.060
48 Dichlorobromomethane		<0.010
51 Chlorodibromomethane		<0.010
66 Bis(2-ethylhexyl)phthalate	<0.010	
68 Di-N-butyl phthalate	<0.010	
85 Tetrachloroethylene		<0.010
86 Toluene	0.030	0.090
87 Trichloroethylene	<0.010	0.030
102 Alpha-BHC		<0.005
105 Delta-BHC		<0.005
Total Toxic Organics	0.050	0.023
Cyanide	<0.005	0.002
TOXIC INORGANICS		
114 Antimony		0.052
115 Arsenic		0.037
117 Beryllium		<0.005
118 Cadmium		1.310
119 Chromium		1.230
120 Copper	Not Analyzed	0.045
122 Lead		1.960
123 Mercury		<0.001
124 Nickel		0.047
125 Selenium		0.002
126 Silver		<0.001
127 Thallium		<0.001
128 Zinc		7.310
NON-CONVENTIONAL POLLUTANTS		
Calcium		23.200
Magnesium		8.380
Sodium		454.
Aluminum		4.100
Manganese		0.037
Vanadium		0.002
Boron		9.420
Barium	Not Analyzed	0.186
Molybdenum		<0.035
Tin		<0.025
Yttrium		0.237
Cobalt		<0.050
Iron		9.930
Titanium		0.045
Phenols	0	0.046
Total Organic Carbon	130	101
Fluoride	45	480
CONVENTIONAL POLLUTANTS		
pH		7.2
Oil & Grease	505	49
Biochemical Oxygen Demand	48	71
Total Suspended Solids	1080	63

TABLE 5-5
PICTURE TUBE PROCESS WASTES
PLANT 99796

Stream Identification	Clarifier Influent	Clarifier Effluent	Clarifier Influent
Sample Number	1	2	3
Flow Rate Liters/Hr/Gallon/day	85626/542880	85626/542880	74950/475200
Duration/Hours/Day	24	24	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS			
23 Chloroform	0.050	0.035	0.030
87 Trichloroethylene	0.025	0.021	
Total Toxic Organics	0.075	0.056	0.030
121 Cyanide	<0.01	0.02	<0.01
TOXIC INORGANICS			
114 Antimony	0.040	0.060	0.040
115 Arsenic	0.030	<0.010	0.030
117 Beryllium	<0.001	<0.001	<0.001
118 Cadmium	0.637	0.021	0.434
119 Chromium	0.776	0.150	0.900
120 Copper	0.016	<0.004	0.012
122 Lead	20.100	0.400	5.300
123 Mercury	<0.0002	0.0002	0.0004
124 Nickel	<0.015	<0.015	<0.015
125 Selenium	<0.010	<0.010	<0.010
126 Silver	<0.012	<0.003	<0.015
127 Thallium	<0.010	<0.010	<0.010
128 Zinc	31.600	0.944	8.77
NON-CONVENTIONAL POLLUTANTS			
Phenols	<0.02	<0.02	<0.02
Flouride	34	32	26
CONVENTIONAL POLLUTANTS			
Oil & Grease	5	5	5
Biochemical Oxygen Demand	17	10	16
Total Suspended Solids	410	15	320

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TABLE 5-5
Picture Tube Process Wastes
Plant 99796 - continued

Stream Identification	Clarifier Effluent	Clarifier Influent	Clarifier Effluent
Sample Number	4	5	6
Flow Rate Liters/Hr/Gallon/day	74950/475200	84500/535680	84500/535680
Duration/Hours/Day	24	24	24
	mg/l	mg/l	mg/l
TOXIC ORGANICS			
23 Chloroform	0.054	0.124	0.024
44 Methylene Chloride	0.008	0.026	0.021
87 Trichloroethylene	0.008		
Total Toxic Organics	0.054	0.150	0.045
121 Cyanide	<0.01	<0.01	0.01
TOXIC INORGANICS			
114 Antimony	0.040	0.100	0.060
115 Arsenic	<0.010	0.50	<0.010
117 Beryllium	<0.001	<0.001	<0.001
118 Cadmium	0.021	0.807	0.014
119 Chromium	0.176	1.300	0.164
120 Copper	<0.004	0.008	<0.004
122 Lead	0.200	13.600	0.300
123 Mercury	0.0004	0.0002	0.0002
124 Nickel	<0.015	0.030	<0.015
125 Selenium	<0.010	<0.010	<0.010
126 Silver	<0.006	<0.015	<0.003
127 Thallium	<0.010	<0.010	<0.010
128 Zinc	0.345	18.800	0.360
NON-CONVENTIONAL POLLUTANTS			
Phenols	<0.02	0.02	0.02
Fluoride	26	35	32
CONVENTIONAL POLLUTANTS			
Oil & Grease	<5	5	5
Biochemical Oxygen Demand	15	18	15
Total Suspended Solids	20	410	10

TSS
Fluoride
Cadmium
Lead
Zinc
Toxic Organics

The process steps associated with the sources of these pollutants are described in Section 4. Table 5-2 summarizes the occurrence and levels at which these pollutants are found based on the sampling and analysis of wastewater from three television picture tube manufacturing facilities. Concentrations represent total raw wastes after flow-proportioning individual plant streams. Figures 5-1, 5-2, and 5-3 identify sampling locations, and Tables 5-3, 5-4, and 5-5 summarize analytical data and wastewater flows obtained from each of the plants sampled.

pH -- may be very high or very low. High pH results from caustic cleaning operations. Low pH results from the use of acids for etching and cleaning operations.

Total Suspended Solids -- are common in cathode ray tube manufacture wastewater and result primarily from graphite emulsions (DAG) used to coat the inner and outer surfaces of glass panels and funnels. Sources include both manufacture and salvage cleaning operations.

Fluoride -- has as its source the use of hydrofluoric acid for cleaning and conditioning glass surfaces. Sources of fluoride in wastewater include both manufacture and salvage operations.

Cadmium and Zinc -- are the major toxic metals found in phosphors used in cathode ray tubes. Sources for these metals in wastewater include manufacture, salvage, and phosphor recovery operations.

Chromium -- occurs as dichromate in photosensitive materials used to prepare glass surfaces for phosphor application. Sources of chromium in wastewater include both manufacture and salvage operations.

Lead -- is present in high concentration in the solder or frit used to fuse glass panels and funnels together. The major source of lead in wastewater occurs in tube salvage operations when acids are used to dissolve the frit and to clean the panels and funnels.

Toxic Organics -- result from the use of solvents such as methylene chloride and trichloroethylene for cleaning and degreasing operations and from toluene-based lacquer coatings applied as a sealant over phosphor coatings. Only limited sampling has been conducted for toxic organics in this subcategory.

5.3 LUMINESCENT MATERIALS

5.3.1 Wastewater Flow

Presented below is a summary of the quantities of wastewater generated by the manufacturers of luminescent materials.

Number of Plants	Wastewater Discharge (gpd) Min.	Mean	Max.
5	10,000	104,000	247,000

5.3.2 Wastewater Sources

Process wastewater sources from the manufacture of luminescent materials include the various crystallization, washing, and filtration steps in the production of intermediate and final product powders. Additional sources are wet scrubbers used in conjunction with firing and drying operations.

5.3.3 Pollutants Found and the Sources of These Pollutants

The major pollutants of concern from the luminescent materials subcategory are:

pH TSS Antimony Cadmium
Zinc

The process steps associated with the sources of these pollutants are described in Section 4. Table 5-6 summarizes the occurrence and levels of these pollutants based on sampling and analysis data. Concentrations represent total raw wastes after flow-proportioning individual plant waste streams. Figure 5-4 identifies the sampling location at one facility. Tables 5-7 through 5-9 present the analytical data for three sampled plants in the luminescent materials subcategory.

pH -- may be very low or very high in specific waste streams as a result of acids used for dissolving raw materials and caustics used in wet scrubbers.

Total Suspended Solids -- occur in wastes from washing and filtration operations and in wet scrubber wastes. The solids primarily consist of precipitated product materials and raw material impurities.

Fluoride -- occurs in wastewaters from lamp phosphor manufacture. Calcium fluoride, as an intermediate powder product, appears in wastes from washing and filtration operations.

Antimony -- used as an activator in the manufacture of lamp phosphors was detected at a high concentration in one raw waste stream.

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TABLE 5-6

LUMINESCENT MATERIALS
SUMMARY OF RAW WASTE DATA

	CONCENTRATION, mg/l		
PARAMETER	MINIMUM	MAXIMUM	MEAN
TOXIC METALS			
114 Antimony	0.021	6.62	2.69
115 Arsenic	0.005	0.020	0.013
117 Beryllium	0.003	0.008	0.005
118 Cadmium	0.216	9.35	4.06
119 Chromium	0.025	0.067	0.155
120 Copper	0.005	0.101	0.051
122 Lead	0.009	0.155	0.064
123 Mercury	0.001	0.005	0.003
124 Nickel	0.025	0.745	0.322
125 Selenium	0.005	0.005	0.005
126 Silver	0.015	0.044	0.025
127 Thallium	0.027	0.065	0.041
128 Zinc	2.864	350.6	120.6
Total Toxic Organics	0.060	1.292	0.590
Oil and Grease	2.64	6.40	3.01
Biochemical Oxygen Demand	2	8	5
Total Suspended Solids	91	4008	1440
Fluoride	11.05	702	356.5

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Cadmium and Zinc -- as the major metals found in blue (Zn) and green (Zn, Cd) TV phosphors, occur as sulfides in the intermediate and final products. Therefore they appear in wastewaters from all washing and filtering operations in the production of blue and green phosphors.

Other toxic metals which are used in very small amounts as activators (arsenic in lamp phosphors and silver and copper in TV phosphors) were detected in very low concentrations.

Toxic Organics -- in the form of phthalate esters, were found in significant concentrations in several process wastes. According to industry personnel, phthalates are not used in the manufacturing process. The presence of these organics may be due to sample contamination, since they also occurred in significant concentrations in sample blanks, or they may result from the use of plastic storage containers.

5.4 RECEIVING AND TRANSMITTING TUBES

No plants were sampled in the Receiving and Transmitting Tube subcategory. Information obtained from plant surveys and industry contacts indicated that wastewater generated by the Receiving and Transmitting Tube subcategory results primarily from processes associated with metal finishing operations.

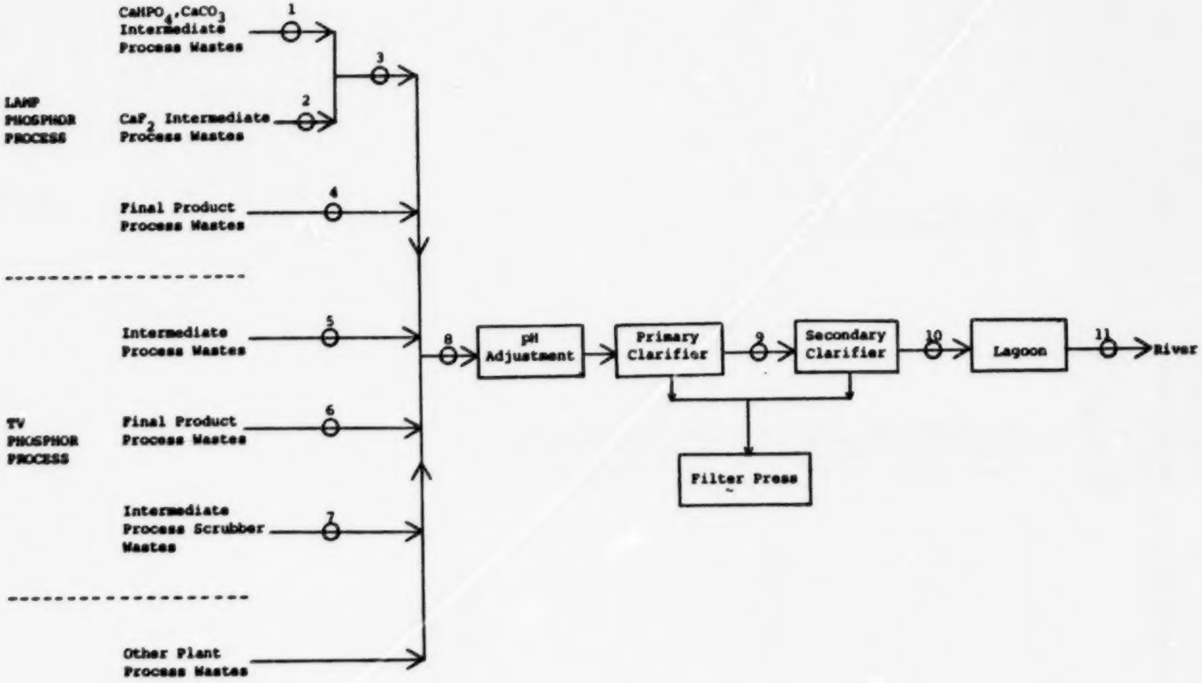
LAMP PHOSPHOR PROCESS
$CaHPO_4$, $CaCO_3$ Intermediate Process Wastes
1
CaF_2 Intermediate Process Wastes
2
3
Final Product Process Wastes
4
TV PHOSPHOR PROCESS
Intermediate Process Wastes
5
Final Product Process Wastes
6
Intermediate Process Scrubber Wastes
7
Other Plant Process Wastes
8
pH Adjustment
Primary Clarifier
9
Secondary Clarifier
10
Lagoon
11
River
Filter Press

FIGURE 5- 4

PLANT 101 SAMPLING LOCATIONS

TABLE 5-7
LAMP PHOSPHOR WASTES
PLANT 101

Stream Identification	Calcium Intermediate Powder Wastes	Fluoride Intermediate Powder Wastes
Sample Number	1	2
Flow Rate Liters/Hr-Gallon/day	26810/170000	946/6000
	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
TOXIC INORGANICS		
114 Antimony	0.016	0.013
115 Arsenic	0.003	0.024
117 Beryllium	<0.003	<0.003
118 Cadmium	0.076	<0.030
119 Chromium	0.070	0.020
120 Copper	0.050	0.020
122 Lead	<0.020	<0.020
123 Mercury	0.005	0.004
124 Nickel	0.220	0.090
125 Selenium	<0.005	<0.005
126 Silver	0.05	0.010
126 Thallium	<0.030	<0.030
128 Zinc	0.005	0.289
NON-CONVENTIONAL POLLUTANTS		
Magnesium	2.704	
Sodium	211.345	
Aluminum	2.598	
Manganese	0.029	0.030
Vanadium	0.252	
Boron	0.633	
Barium	0.402	
Molybdenum	8.378	
Tin	0.418	
Yttrium	0.230	
Cobalt	0.100	
Iron	0.208	
Titanium	0.127	
Fluoride		100
CONVENTIONAL POLLUTANTS		
Biochemical Oxygen Demand	<3	
Total Suspended Solids	840	1100

TABLE 5-7
LAMP PHOSPHOR WASTES
PLANT 101

Stream Identification	Composites 1 & 2	Fired Lamp Powder Wastes
Sample Number	3	4
Flor Rate Liters/Hr-Gallon/day	27760/176000	3785/24000
	mg/l	mg/l
TOXIC ORGANICS		
11 1,1,1-Trichloroethane		<0.010
23 Chloroform	<0.010	<0.010
44 Methylene Chloride	0.012	0.011
66 Bis(2-ethylhexyl)phthalate	0.470	1.200
67 Butyl benzyl phthalate	0.960	<0.010
68 Di-N-butyl phthalate	0.15	<0.010
70 Diethyl Phthalate	<0.010	
Total Toxic Organics	1.437	1.211
121 Cyanide	<0.004	<0.004
TOXIC INORGANICS	Not Analyzed	
114 Antimony		14.669
115 Arsenic		0.116
117 Beryllium		<0.003
118 Cadmium		26.210
119 Chromium		0.050
120 Copper		0.040
122 Lead		0.080
123 Mercury		0.003
124 Nickel		0.290
125 Selenium		<0.005
126 Silver		0.020
127 Thallium		<0.030
128 Zinc		0.071
NON-CONVENTIONAL POLLUTANTS		
Magnesium		0.680
Sodium		2.288
Aluminum		1.189
Manganese		32.250
Vanadium		0.050
Boron		1.721
Barium		0.040
Molybdenum		0.050
Tin		0.028
Yttrium		0.037
Cobalt		0.005
Phenols	<0.002	<0.002
Total Organic Carbon	8.0	170
Fluoride		7200
Ammonia		3.4
CONVENTIONAL POLLUTANTS		
Total Suspended Solids		3200

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TABLE 5-7
TV PHOSPHOR WASTES
PLANT 101

Stream Identification	Intermediate Powder Wastes	Phosphor Wastes	Scrubber Wastes
Sample Number	5	6	7
Flow Rate Liters/Hr-Gallon/day	4732/30000	1577/10000	1104/7000
	mg/l	mg/l	mg/l
TOXIC ORGANICS			Not Analyzed
11 1,1,1-Trichloroethane	<0.01	<0.01	
44 Methylene Chloride	0.018	0.014	
66 Bis(2-ethylhexyl)phthalate	1.100	1.200	
67 Butyl benzyl phthalate	<0.01	<0.01	
68 Di-N-butyl phthalate	<0.01	<0.01	
70 Diethyl Phthalate	<0.01		
Total Toxic Organics	1.118	1.214	
121 Cyanide	<0.004	<0.004	
TOXIC INORGANICS			
114 Antimony	0.021	0.011	0.049
115 Arsenic	<0.001	<0.001	0.040
117 Beryllium	<0.003	<0.003	<0.003
118 Cadmium	0.077	<0.030	0.058
119 Chromium	0.055	<0.005	0.080
120 Copper	0.020	0.010	0.150
122 Lead	0.050	0.020	<0.020
123 Mercury	0.006	0.002	0.007
124 Nickel	0.040	<0.020	1.290
125 Selenium	<0.005	<0.005	0.005
126 Silver	0.010	<0.003	0.230
127 Thallium	<0.030	<0.030	<0.030
128 Zinc	2,590	888.5	0.194
NON-CONVENTIONAL POLLUTANTS			
Calcium	1.311	2.219	2.819
Magnesium	0.083	13.670	0.035
Sodium	1.036	2.696	
Aluminum	0.015	0.771	2.821
Manganese	0.020	0.026	0.017
Vanadium	<0.001	0.114	0.201
Boron	0.021	0.038	0.043
Barium	0.007	0.004	0.033
Molybdenum	2.826	1.006	1.903
Tin	0.224	0.053	0.407
Yttrium	<0.001	0.037	0.699
Cobalt	0.043	0.080	0.068
Iron	0.417	0.142	0.308
Titanium	0.020	0.007	0.048
Phenols	<0.002	<0.002	
Total Organic Carbon	20	4.0	
CONVENTIONAL POLLUTANTS			
Total Suspended Solids	24,700	1500	1100

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TABLE 5-7
TREATMENT SYSTEMS
PLANT 101

Stream Identification	Treatment Influent	Primary Clarifier Effluent
Sample Number	8	9
Flow Rate Liters/Hr-Gallon/day	189270/1200000	189270/1200000
	mg/l	mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
TOXIC INORGANICS		
114 Antimony	0.029	0.058
115 Arsenic	0.078	<0.001
117 Beryllium	<0.030	<0.003
118 Cadmium	0.337	0.091
119 Chromium	1.730	0.120
120 Copper	0.150	0.090
122 Lead	<0.020	<0.020
123 Mercury	0.003	0.005
124 Nickel	0.260	0.330
125 Selenium	<0.005	<0.005
126 Silver	0.040	0.010
126 Thallium	<0.030	<0.030
128 Zinc	5.517	0.419
NON-CONVENTIONAL POLLUTANTS		
Calcium	302.707	513.207
Magnesium	88.120	129.602
Aluminum	3.052	2.399
Manganese	0.783	0.260
Vanadium	0.804	0.872
Boron	1.500	0.948
Barium	0.319	0.099
Molybdenum	0.958	0.568
Tin	0.285	0.257
Europium	<0.05	<0.01
Yttrium	<2	<2
Cobalt	1.153	0.373
Iron	133.988	3.560
Titanium	0.095	0.077
CONVENTIONAL POLLUTANTS		
Total Suspended Solids	210	110

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TABLE 5-7
TREATMENT SYSTEMS
PLANT 101 - continued

Stream Identification	Secondary Clarifier Effluent	Final Effluent
Sample Number	10	11
Flow Rate Liters/Hr/Gallon/day	189270/1200000 mg/l	189270/1200000 mg/l
TOXIC ORGANICS	Not Analyzed	Not Analyzed
TOXIC INORGANICS		
114 Antimony	0.146	0.031
115 Arsenic	0.156	0.008
117 Beryllium	<0.003	<0.003
118 Cadmium	0.512	0.020
119 Chromium	4.750	0.050
120 Copper	0.220	0.030
122 Lead	<0.020	<0.020
123 Mercury	0.003	0.004
124 Nickel	0.450	0.130
125 Selenium	<0.005	<0.005
126 Silver	0.060	0.020
127 Thallium	<0.030	<0.030
128 Zinc	11.409	0.289
NON-CONVENTIONAL POLLUTANTS		
Calcium		240.200
Magnesium		52.730
Aluminum		0.090
Manganese		0.107
Vanadium		0.368
Boron		0.361
Barium		0.091
Molybdenum		0.128
Tin		0.023
Europium	<0.1	<0.05
Yttrium	<2	<2
Cobalt		0.096
Iron		4.237
Titanium		0.005
CONVENTIONAL POLLUTANTS		
Total Suspended Solids	730	45

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TABLE 5-8
TV PHOSPHOR WASTES
PLANT 102

Stream Identification	Luminescent Material Waste	Final Plant Effluent
Sample Number	1	2
Flow Rate Liters/Hr/Gallon/day	4360/9000 mg/l	39430/250000 mg/l
TOXIC ORGANICS		
23 Chloroform	0.005	
66 Bis(2-ethylhexyl)phthalate	0.060	0.260
68 Di-N-butyl phthalate	0.006	
86 Toluene		0.010
87 Trichloroethylene		0.060
Total Toxic Organics	0.060	0.33
121 Cyanide	<0.002	0.004
TOXIC INORGANICS		
114 Antimony	0.021	0.008
115 Arsenic	<0.005	<0.005
117 Beryllium	<0.005	<0.005
118 Cadmium	0.216	0.200
119 Chromium	<0.025	0.200
120 Copper	0.005	0.325
122 Lead	0.009	0.004
123 Mercury	<0.001	<0.001
124 Nickel	<0.025	0.190
125 Selenium	<0.005	<0.005
126 Silver	<0.015	0.015
126 Thallium	0.027	0.038
128 Zinc	8.450	0.468
NON-CONVENTIONAL POLLUTANTS		
Phenols	0.012	
Total Organic Carbon	31	6.8
CONVENTIONAL POLLUTANTS		
pH @ 23^{o}C	11.1	6.8
Oil & Grease	6.4	8.0
Biochemical Oxygen Demand		8
Total Suspended Solids	91	12

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TABLE 5-9
LAMP PHOSPHOR WASTES
PLANT 103

	Stream Identification	Special Phosphors Wastes	Lamp Phosphor Wastes
	Sample Number	1	2
	Flow Rate Liters/Hr-Gallon/day	79/500	790/5000
		mg/l	mg/l
	TOXIC ORGANICS		
1	Acenaphene	<0.010	
4	Benzene	<0.010	<0.010
23	Chloroform	<0.010	<0.010
39	Fluoranthene	<0.010	
44	Methylene Chloride	0.160	0.150
66	Bis(2-ethylhexyl)phthalate	<0.010	<0.010
67	Butyl Benzyl phthalate	<0.160	<0.010
68	Di-N-butyl phthalate	<0.010	0.011
70	Diethyl phthalate	0.036	0.260
78	Anthrancene	<0.010	0.010
81	Phenanthrene	<0.010	<0.010
84	Pyrene	<0.010	
86	Toluene		0.018
106	PCB-1242	0.008	
	Total Total Organics	0.196	0.439
	Cyanide	0	0
	TOXIC INORGANICS		
114	Antimony	0.009	7.278
115	Arsenic	0.006	0.021
117	Beryllium	0.075	<0.001
118	Cadmium	0.091	10.270
119	Chromium	0.266	0.047
120	Copper	0.419	0.069
122	Lead	1.070	0.063
123	Mercury	0.003	0.004
124	Nickel	3.272	0.536
125	Selenium	<0.005	<0.005
126	Silver	0.070	0.010
127	Thallium	<0.030	<0.030
128	Zinc	7.011	2.449
	NON-CONVENTIONAL POLLUTANTS		
	Calcium	8.672	432.007
	Magnesium	3.016	2.070
	Sodium		4.771
	Aluminum	3.854	0.115
	Manganese	0.428	14.060
	Vanadium	14.812	0.034
	Boron	49.802	0.053
	Barium	0.230	0.283
	Molybdenum	0.462	0.030
	Tin	0.286	0.012
	Yttrium	10.602	0.019
	Cobalt	0.117	0.010
	Iron	1.399	0.516
	Titanium	0.079	0.010
	Total Organic Carbon	98	43
	Fluoride	1.5	12
	CONVENTIONAL POLLUTANTS		
	Oil & Grease	29	0
	Total Suspended Solids	270	215

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SECTION 6

SUBCATEGORIES AND POLLUTANTS TO BE REGULATED, EXCLUDED OR DEFERRED

This section cites the E&EC subcategories which are being (1) regulated or (2) excluded from regulation. In addition, this section explains, for those subcategories being regulated, which pollutants are being regulated and which pollutants are being excluded from regulation.

6.1 SUBCATEGORIES TO BE REGULATED

Based on wastewater characteristics presented in Section 5, discharge effluent regulations are being proposed for the Cathode Ray Tube and Luminescent Materials subcategories.

6.1.1 Pollutants to be Regulated

The specific pollutants selected for regulation in these subcategories are: Cathode Ray Tubes - cadmium, chromium, lead, zinc, fluoride, TSS, pH and TTO; and Luminescent Materials - cadmium, zinc, antimony, fluoride, TSS and pH. The rationale for regulating these pollutants is presented below.

(pH) Acidity or Alkalinity

During cathode ray tube and luminescent materials manufacture, both high and low pH levels may occur. High pH results from caustic cleaning operations or caustics used in wet scrubbers while low pH results from the use of acids for etching and cleaning operations.

Although not a specific pollutant, pH is a measure of acidity or alkalinity of a wastewater stream. The term pH is used to describe the hydronium ion balance in water. Technically, pH is the negative logarithm of the hydrogen ion concentration. A pH of 7 indicates neutrality, a balance between free hydrogen and free hydroxyl ions. A pH above 7 indicates that the solution is alkaline, while a pH below 7 indicates that the solution is acidic.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures; this corrosion can add constituents to drinking water such as iron, copper, zinc, cadmium, and lead. Low pH waters not only tend to dissolve metals from structures and fixtures, but also tend to redissolve or leach metals from sludges and bottom sediments. Waters with a pH above 9.9 can corrode certain metals, are detrimental to most natural organic materials, and are toxic to living organisms.

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Total Suspended Solids (TSS)

Total suspended solids found in cathode ray tube manufacture wastewater result primarily from graphite emulsions (DAG) used to coat the inner and outer surfaces of glass panels and funnels. Sources include both manufacture and salvage cleaning operations. The average concentration of TSS in CRT wastewaters is 87.5 mg/l. TSS concentrations in the effluent from the manufacture of luminescent materials average 1,440 mg/l. These solids consist primarily of precipitated product materials and raw material impurities. Major sources are washing and filtration operations and wet scrubber wastes.

Suspended solids increase the turbidity of water, reduce light penetration, and impair the photosynthetic activity of aquatic plants. Solids, when transformed to sludge deposit, may blanket the stream or lake bed and destroy the living spaces for those benthic organisms that would otherwise occupy the habitat.

Total Toxic Organics (TTO)

Total toxic organics (TTO) are found in the wastewaters from cathode ray tube facilities. TTO is considered the sum of the concentrations of toxic organics listed in Table 6-1 which are found at concentrations greater than 0.01 milligrams per liter. These organics result from the use of solvents (e.g., methylene chloride, trichloroethylene) for cleaning and degreasing operations and from toluene-based lacquer coatings applied as a sealant over phosphor coatings. Maximum TTO concentrations of 0.15 milligrams per liter were found in the process wastes from cathode ray tube facilities.

Table 6-1
Pollutants Comprising Total Toxic Organics

Toxic Pollutant No.			
8	1,2,4-trichlorobenzene	54	isophorone
11	1,1,1-Trichloroethane	55	naphthalene
21	2,4,6-trichlorophenol	57	2-nitrophenol
23	Chloroform	58	4-nitrophenol
24	2-chlorophenol	64	pentachlorophenol
25	1,2-dichlorobenzene	65	phenol
26	1,3-dichlorobenzene	66	bis(2-ethylhexyl)phthalate
27	1,4-dichlorobenzene	67	butyl benzyl phthalate
29	1,1-dichloroethylene	68	di-n-butyl phthalate
31	2,4-dichlorophenol	78	anthracene
37	1,2-diphenylhydrazine	85	tetrachloroethylene
38	ethylbenzene	86	toluene
44	methylene chloride	87	trichloroethylene

Antimony

Antimony is being regulated only in the Luminescent Materials subcategory. It is used in small amounts as an activitor in the manufacture of lamp phosphors and was detected at a high concentration in a sampled raw waste stream. The mean concentration of antimony for luminescent materials facilities was 2.69 milligrams per liter.

Antimony compounds are poisonous to humans and are classed as acutely moderate or chronically severe. Antimony can be concentrated by certain forms of aquatic life to over 300 times the background concentrations. In tests on various fish and aquatic life, the salts of antimony give mixed results on toxicity dependent on the salt, temperature, hardness of the water, and dissolved oxygen present.

Cadmium

Cadmium is found in the wastewater from both cathode ray tube and luminescent materials facilities at mean concentrations of 0.374 milligrams per liter and 4.06 milligams per liter, respectively. Cadmium is one of the major metals found in blue and green TV phosphors and appears in wastewaters from all washing and filtering operations in the production of these phosphors. In the CRT industry, cadmium results from manufacture, salvage and phosphor recovery operations.

Cadmium is a cumulative toxicant, causing progressive chronic poisoning in mammals, fish and other animals. It is known to have marked acute and chronic effects on aquatic organisms. The compound is highly concentrated by marine organisms, primarily molluscs. The eggs and larvae of fish are apparently more sensitive than adult fish to poisoning by cadmium, and crustaceans appear to be even more sensitive than fish eggs and larvae. Cadmium in drinking water supplies is extremely hazardous to humans, and conventional treatment does not remove it. It also acts synergistically with other metals; copper and zinc substantially increase its toxicity.

Chromium

Chromium is found in the wastewaters from the Cathode Ray Tube subcategory. It occurs as dichromate in photosensitive materials used to prepare glass surfaces for phosphor application. The mean concentration of chromium in wastewater from manufacture and salvage operations range was 1.31 milligrams per liter.

Chromium is considered hazardous to man, producing lung tumors when inhaled and inducing skin sensitizations. The toxicity of chromium salts to fish, and other aquatic life varies widely with the species, temperature, pH, valence of chromium and synergistic or antagonistic effects. It appears that fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium, which also appears to inhibit algal growth.

Lead

Lead is being regulated in the Cathode Ray Tube subcategory. It is present in the solder or frit used to fuse glass panels and funnels together. The major sources of lead in CRT wastewaters are tube salvage operations where acids are used to dissolve the frit and to clean the panels and funnels. The mean concentration of lead for CRT facilities was 9.41 milligrams per liter.

Lead levels are cumulative in the human body over long periods of time with chronic ingestion of low levels causing poisoning over a period of years. Fish have been shown to have adverse effects from lead and lead salts in the environment. Small concentrations of lead may cause a film of coagulated mucus to form over the fish, leading to suffocation.

Zinc

Zinc is being regulated in both the Cathode Ray Tube and Luminescent Materials subcategories. As with cadmium, zinc is one of the major toxic metals found in phosphors. Sources of zinc are therefore the same as discussed above for cadmium. Mean zinc concentrations for the two industries are 11.79 milligrams per liter (cathode ray tube) and 120.6 milligrams per liter (luminescent materials).

Zinc can have an adverse effect on man and animals at high concentrations while lower zinc levels in public water supply sources can cause an undesirable taste which persists through conventional treatment. The toxicity of zinc to fish has been shown to vary with fish species, age and condition, as well as with the physical and chemical characteristics of the water.

Fluoride

Fluoride is found in the wastewaters of cathode ray tube and luminescent materials facilities from both manufacture and salvage operations. The source of fluoride from CRT manufacture is the use of hydrofluoric acid for cleaning and conditioning glass surfaces. The mean concentration in CRT process wastes was 360.6. The source of fluoride from luminescent materials manufacture is an intermediate powder in lamp phosphor production. The mean concentration of fluoride at luminescent materials facilities was 356.5 milligrams per liter.

Although fluoride is not listed as a toxic pollutant, it can be toxic to livestock and plants, and can cause tooth mottling in humans. The National Academy of Sciences recommends: (1) two milligrams per liter as an upper limit for drinking water and watering livestock and, (2) one milligram per liter for continuous use as irrigation water on acid soils to prevent plant toxicity and reduced crop yield. Although some fluoride in drinking water helps to prevent tooth decay, EPA's National

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Interim Primary Drinking Water Regulations set limits of 1.4 to 2.4 milligrams per liter in drinking water to protect against tooth mottling.

6.2 TOXIC POLLUTANTS AND SUBCATEGORIES NOT REGULATED

The Settlement Agreement, explained in Section 2, contained provisions authorizing the exclusion from regulation, in certain circumstances, of toxic pollutants and industry categories and subcategories. These provisions have been rewritten in a Revised Settlement Agreement which was approved by the District Court for the District of Columbia on March 9, 1979, NRDC v. Costle, 12 ERC 1833.

6.2.1 Exclusion of Pollutants

Ninety-six (96) toxic pollutants are being excluded from regulation for both the Cathode Ray Tube and Luminescent Materials subcategories. The basis for exclusion for eighty-six; (86) of these pollutants is Paragraph 8(a)(iii) which allows exclusion for pollutants which are not detectable with state-ofthe-art analytical methods. The basis of exclusion for another nine of these pollutants is also provided by Paragraph 8(a)(iii) which allows exclusion of pollutants which are present in amounts too small to be effectively reduced.

The nine toxic pollutants that are being excluded from both subcategories under Paragraph 8(a)(iii) are: arsenic, beryllium, copper, mercury, nickel, selenium, silver, thallium, and cyanide.

The eighty-six which are being excluded under 8(a)(iii) because they were not detected are presented in Table 6-2.

6.2.2 Exclusion of Subcategories

All subcategory exclusions are based on either Paragraph 8(a)(i), or Paragraph 8(a)(iv) of the Revised Settlement Agreement. Paragraph 8(a)(i) permits exclusion of a subcateogry for which "equally or more stringent protection is already provided by an effluent, new source performance, or pretreatment standard or by an effluent limitation. . ." Paragraph 8(a)(iv) permits exclusion of a category or subcategory where "the amount and the toxicity of each pollutant in the discharge does not justify developing national regulations . . ." These exclusions are supported by data and information presented in Section 5.

The Receiving and Transmitting Tube subcategory is being excluded from regulation under the provisions of Paragraph 8(a)(i) on the basis that the assembly of these tubes is a dry process. Those unit operations which use water for cleaning, degreasing, and plating are covered under metal finishing limitations.

TABLE 6-2

TOXIC POLLUTANTS NOT DETECTED

1. Acenaphthene
2. Acrolein
3. Acrylonitrile
4. Benzene
5. Benzidine
6. Carbon Tetrachloride
7. Chlorobenzene
9. Hexachlorobenzene
10. 1,2-Dichloroethane
12. Hexachloroethane
13. 1,1-Dichloroethane
14. 1,1,2-Trichloroethane
15. 1,1,2,2-Tetrachloroethane
16. Chloroethane

18. Bis(2-Chloroethyl)Ether
19. 2-Chloroethyl Vinyl Ether (Mixed)
20. 2-Chloronaphthalene
22. Parachlorometa Cresol
28. 3,3'-Dichlorobenzidine
30. 1,2-Trans-Dichloroethylene
32. 1,2-Dichloropropane
33. 1,2-Dichloropropylene
34. 2,4-Dimethylphenol
35. 2,4-Dinitrotoluene
36. 2,6-Dinitrotoluene
39. Fluorathene
40. 4-Chlorophenyl Phenyl Ether
41. 4-Bromophenyl Phenyl Ether
42. Bis(2-chloroisopropyl) Ether
43. Bis-(2-chloroethoxy) Methane
45. Methyl Chloride
46. Methyl Bromide
47. Bromoform
48. Dichlorobromomethane

51. Chlorodibromomethane
52. Hexachlorobutadiene
53. Hexachlorocyclopentadiene
56. Nitrobenzene
59. 2,4-dinitrophenol
60. 4,6-dinitro-o-cresol
61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine
69. Di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate
72. Benzo(a)anthracene
73. Benzo(a)pyrene
74. 3,4-benzofluorathene
75. Benzo(k)fluoranthane
76. Chrysene
77. Acenaphthylene
79. Benzo(ghi)perylene
80. Fluorene
81. Phenanthrene
82. Dibenzo(a,h)anthracene
83. Ideno(1,2,3-cd)pyrene
84. Pyrene
88. Vinyl Chloride
89. Aldrin
90. Dieldrin
91. Chlordane
92. 4,4'-DDT
93. 4,4'-DDE
94. 4,4'-DDD
95. A-endosulfan-Alpha
96. B-endosulfan-Beta
97. Endosulfan Sulfate
98. Endrin
99. Endrin Aldehyde
100. Heptachlor
101. Heptachlor Epoxide
102. A-BHC-Alpha
103. R-BHC-Beta
104. BHC-Gamma
105. BHC-Delta
106. PCB-1242
107. PCB-1254
108. PCB-1221
109. PCB-1232
110. PCB-1248
111. PCB-1260
112. PCB-1016
113. Toxaphene
116. Asbestos
129. 2,3,4,8-tetrachlorodibenzo-p-dioxin

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Existing direct dischargers in the Cathode Ray Tube subcategory are being excluded from regulation under the provisions of Paragraph 8(a)(iv). Only one plant of the 22 plants in the Cathode Ray Tube subcategory is a direct discharger and that plant has precipitation/clarification plus filtration treatment in place. The discharge of toxic pollutants is insignificant, less than 2 pounds/day after current treatment.

All existing dischargers in the Luminescent Materials subcategory are being excluded from regulation. Of the five plants in this subcategory, only two are direct dischargers. These two plants discharge after treatment less than one pound/plant of toxic metals per day. For this reason, exclusion under the provision fo paragraph 8(a)(iv) is proposed. In the case of the indirect dischargers, exclusion under the provision of paragraph 8(b)2 is proposed on the basis that the amount of toxic pollutants introduced into POTW's is insignificant.

6.3 CONVENTIONAL POLLUTANTS NOT REGULATED

BOD, and oil and grease are not being regulated for either subcategory because they were found at concentrations below treatability. BOD was found at an average of 7.4 milligrams per liter in cathode ray tube facilities and 5 milligrams per liter in luminescent materials plants; oil and grease was found at an average concentration of 9.1 milligrams per liter in cathode ray tube plants and 3.0 milligrams per liter in luminescent materials plants; and fecal coliform was not present in the process discharge from either subcategory.

SECTION 7

CONTROL AND TREATMENT TECHNOLOGY

The wastewater pollutants of concern in the manufacture of cathode ray tubes and luminescent materials, as identified in Section 5, are pH, suspended solids, fluoride, antimony, chromium, cadmium, lead, zinc, and toxic organics. A discussion of the treatment technologies currently practiced and most applicable for the reduction of these pollutants is presented below followed by an identification of three recommended treatment and control systems and an analysis of the performance of these systems.

7.1 CURRENT TREATMENT AND CONTROL PRACTICES

Pollutant control technologies currently used in the cathode ray tube and luminescent materials industries include both in-process and end-of-pipe technologies. In-process waste control technologies are meant to remove pollutants from process wastewater by treatment at some point in the manufacturing process, or to limit the introduction of pollutants into process wastewater by control techniques. End-of-pipe treatment is wastewater treatment at the point of discharge.

7.1.1 Cathode Ray Tube Subcategory

In-process Control -- In-process control techniques with widespread use in this subcategory are collection of spent solvents for resale, reuse or disposal, and segregation of spent acid wastes for contract hauling. Contract hauling refers to the industry practice of contracting a firm to collect and transport wastes for off-site disposal.

All color television tube manufacturing plants are known to collect spent solvents for either contractor disposal or reclaim. Two plants also have their lead-bearing nitric acid wastes contract-hauled. Three plants have in-process treatment of chromium wastes, and two of these plants also have in-process treatment of strong lead-bearing wastes. Information from single phosphor tube manufacturers indicates that in-process control of pollutants at these facilities is limited to collection and contract hauling of solvent wastes.

End-of-Pipe Treatment -- Six of the seven color television tube manufacturers use end-of-pipe precipitation/clarification for control of toxic metals. The one plant which currently only neutralizes its discharge is planning a new treatment system for control of metals. The one direct discharger also filters its treated process wastewater prior to discharge.

Information from single phosphor tube manufacturers indicates that most facilities only neutralize their wastes. Some small plants have provisions for solids removal prior to discharge. Two plants have combined treatment systems designed to treat metal finishing wastes from other plant manufacturing operations.

7.1.2 Luminescent Materials Subcategory

In the Luminescent Materials subcategory the two direct dischargers have combined end-of-pipe treatment systems that utilize precipitation/clarification technologies. Of the three other plants in the subcategory, one evaporates its liquid waste and has no industrial discharge, one neutralizes its wastes end-of-pipe and the third uses precipitation/clarification technology to control toxic metals prior to discharge.

7.2 APPLICABLE TREATMENT TECHNOLOGIES

7.2.1 pH Control

Acids and bases are commonly used in the production of cathode ray tubes and luminescent materials and result in process waste streams exhibiting high or low pH values. Acids and bases are used frequently in cleaning operations for cathode ray tube manufacture. In the production of luminescent materials, acids are used to dissolve raw materials and bases are used in alkaline scrubbers.

Several methods can be used to treat acidic or basic wastes. Treatment is based upon chemical neutralization usually to pH 6-9. Methods include: mixing acidic and basic wastes, and neutralizing high pH streams with acid or low pH streams with bases. The method of neutralization used is selected on the basis of overall cost. Process water can be treated continuously or on a batch basis. Neutralization is often used in conjunction with precipitation of metals.

Hydrochloric or sulfuric acid may be used to neutralize alkaline wastewaters; sulfuric acid is most often chosen because of its lower cost.

Sodium hydroxide (caustic soda), sodium carbonate (soda ash), or calcium hydroxide (lime) may be used to neutralize acidic wastewater. The factors considered in selection include price, neutralization rate, storage and equipment costs, and neutralization end products. Sodium hydroxide is more expensive than most other alkalis but is often selected due to its ease of storage, rapid reaction rate and the general solubility of its end product.

7.2.2 Fluoride Treatment

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Fluoride appears in cathode ray tube manufacture wastewater because of the use of hydrofluoric acid for cleaning and conditioning glass surfaces. In the production of luminescent materials fluoride appears as ammonium bifluoride in the raw material used, and as calcium fluoride in intermediate and final products.

The most common treatment procedure practiced today in the United States for reducing the fluoride concentration in wastewater is precipitation by the addition of lime followed by clarification. Calcium fluoride is formed by the following reaction:

Ca(OH)ZX2 + 2FZQ- = CaFZX2 + 2OHZQ

The solubility of calcium fluoride in water is 7.8 mg fluoride ion per liter at 18ZJC. The precipitate forms slowly, requiring about 24 hours for completion and the solubility of calcium fluoride soon after its formation is about ten milligrams of fluoride per liter.

Data from the Cathode Ray Tube subcategory indicate that plants using precipitation and clarification treatment technologies are achieving an average effluent concentration of 20 milligrams per liter fluoride.

Hydroxide precipitation has proven to be an effective technique for removing many pollutants from industrial wastewater. Metal ions are precipitated as hydroxides and fluoride is precipitated as insoluble calcium fluoride. The system operates at ambient conditions and is well suited to automatic control. Lime is usually added as a slurry when used in hydroxide precipitation. The slurry must be kept well mixed and the addition lines periodically checked to prevent blocking, which may result from a buildup of solids. The use of hydroxide precipitation does produce sludge requiring disposal following precipitation.

The performance of a precipitation system depends on several variables. The most important factors affecting precipitation effectiveness are:

1. Addition of sufficient excess chemicals to drive the precipitation reaction to completion. If treatment chemicals are not present in slight excess concentrations, some pollutants will remain dissolved in the waste stream.

2. Maintenance of an alkaline pH throughout the precipitation reaction and subsequent settling.

3. Effective removal of precipitated solids.

Removal of suspended solids or precipitates by gravitational forces may be conducted in a settling tank, clarifier, or lagoon.

However, the performance of each is a function of the retention time, particle size and density, and the surface area of the sedimentation chamber. Accumulated sludge can be removed either periodically or continuously as in the case of a clarifier.

The effectiveness of a solids settling unit can often be enhanced by the addition of chemical coagulants or flocculants which reduce the repulsive forces between ions or particles and allow them to form larger flocs which are then removed more easily. Commonly used coagulants include ferric sulfate and chloride; commonly used flocculants are organic polyelectrolytes.

7.2.3 Toxic Metals Treatment

Toxic metals appear in process wastewaters from the manufacture of luminescent materials and cathode ray tubes. Zinc and cadmium are major constituents of phosphors and, as such, appear in most process waste streams at luminescent materials manufacturing plants and in many waste streams at cathode ray tube plants. Lead, found in the solder used to fuse cathode ray tube panels and funnels, appears in tube salvage wastes at these plants. Chromium, a constituent of photoresist materials, is found in the hexavalent form in several wastes at cathode ray tube plants.

The most commonly used method to remove toxic metals from wastewaters is to precipitate the metals as hydroxides or carbonates and then remove the insoluble precipitates by clarification or settling.

Hydroxide precipitation uses lime or caustic soda to supply the hydroxide ions. The chemistry of the process is simple but must be understood for each metal. The pH must be in the optimum range to avoid forming soluble complexes. A simple form of the reaction may be written as:

MZQ++ + 2OHZQ- = M(OH)ZX2

The treatment levels attainable by hydroxide precipitation can be forecast from a knowledge of the pH of the system. Figure 7-1 shows the theoretical solubility of those toxic metals which form insoluble hydroxides. It is clear from the figure that for wastewaters containing more than one metal, no single optimum pH exists. For successful application as a wastewater treatment technology, careful control of pH must be practiced if the best removals are to be achieved. In practice, hydroxide precipitation is often supplemented by the use of coagulating agents to improve solids removal.

Sodium carbonate is often the reagent of choice for the treatment of lead-bearing wastes. Lead carbonate or lead hydroxide/ carbonate precipitates are formed which allow improved settling characteristics for this metal.

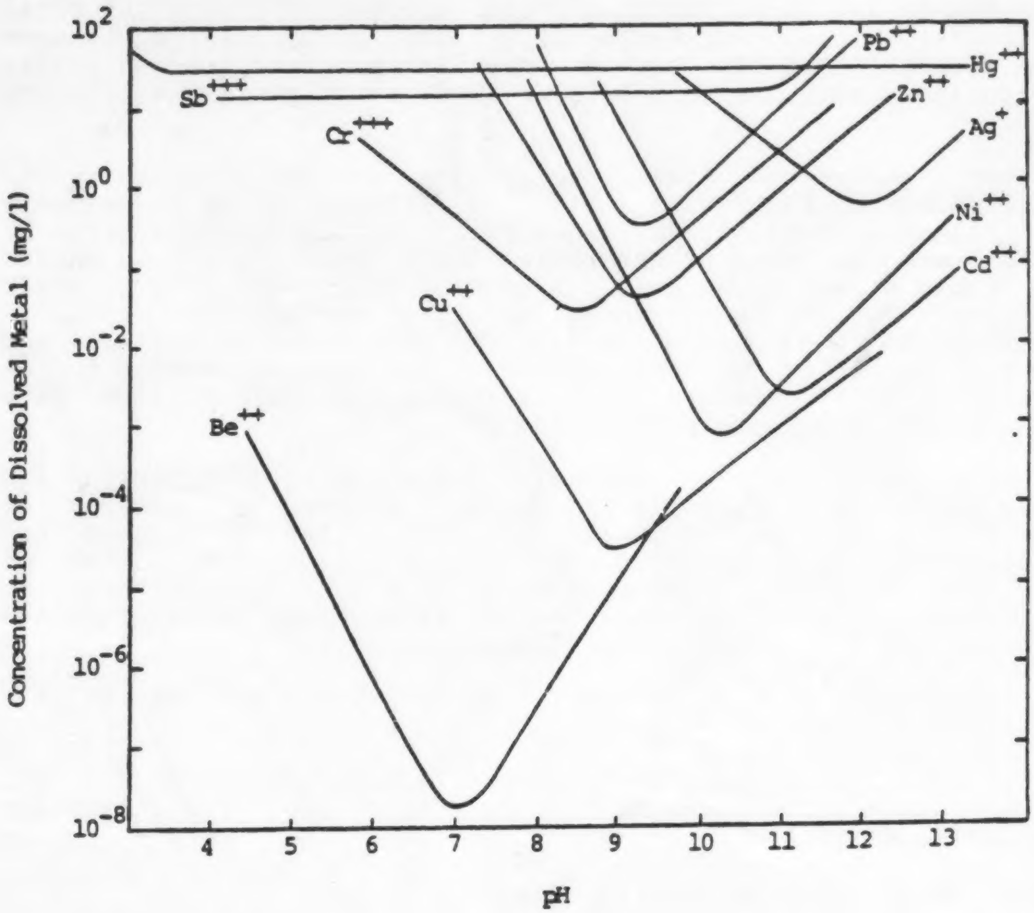

FIGURE 7-1

Theoretical solubilities of toxic metal hydroxides/oxides as a function of pH.

NOTE: Solubilities of metal hydroxides/oxides are from data by M.Pourbaix, Atlas of Electrochemical Equilibria in Aqueous Solutions, Pergamon Press, Oxford, 1966.

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Depending on the quantity of waste flow, the treatment can either be a batch or continuous operation, with batch treatment favored for small flows. In batch treatment the equipment usually consists of two tanks, each with the capacity to direct the total wastewater volume. For large daily flows, a typical continuous flow scheme consists of an equalization tank, flash mixer, flocculator, settling unit or clarifier and a sludge thickening unit.

Further removal of fine precipitates can be achieved by the addition of a filtration unit. A filtration unit commonly consists of a container holding a filter medium or combination of media such as sand or anthracite coal, through which is passed the liquid stream. The unit can operate by gravity flow or under pressure. Periodic backwashing or scraping of the media is necessary to remove particles filtered from the liquid stream and prevent clogging of the filter. The proper design of a filtration unit considers such criteria as filter flow rate (gpm/sq ft), media grain size, and density.

Chromium Reduction -- Hexavalent chromium (e.g. CrOZX4ZQ= and CrZX2OZX7ZQ=) is very toxic and soluble, and must be reduced to the trivalent form (CrZQ+++) before it can be removed from wastewater by precipitation and clarification. A number of chemicals can be used to reduce chromium from the hexavalent to the trivalent form. A typical method uses sodium bisulfite and sulfuric acid at low pH. The reduction reaction is:

3SOZX3ZQ= + CrZX2OZX7ZQ= + 8HZQ+ = 2CrZQ+++ + 3SOZX4ZQ= + 4HZX2O

Following this reduction step, the trivalent chromium is now in a form that can be treated using hydroxide precipitation/ clarification technology.

7.2.4 Total Toxic Organics Control

The sources of toxic organics in the Cathode Ray Tube subcategory are solvents used for cleaning and degreasing operations and toluene-based coatings used to protect phosphors. The primary technique in this subcategory for controlling the discharge of toxic organics is the segregation of spent solvents for contract hauling (disposal) or for sale to companies which purify the solvents in bulk for resale. This control technology of solvent management also includes good housekeeping practices such as controlling leaks and spills.

7.3 RECOMMENDED TREATMENT AND CONTROL SYSTEMS

Based on the pollutants of concern in the Cathode Ray Tube and Luminescent Materials subcategories, applicable treatment technologies for the control of these pollutants, and the current technologies observed within the two subcategories, three options for control and treatment have been identified.

7.3.1 Cathode Ray Tube Subcategory

Option 1 treatment consists of neutralization for pH control.

Option 2 treatment consists of Option 1 treatment with the addition of: chromium reduction with the use of sulfuric acid and sodium bisulfite; chemical precipitation and clarification of all metals-bearing process wastes using lime, sodium carbonate, a coagulant and polyelectrolyte; and sludge dewatering. Option 2 is presented schematically in Figure 7-2.

Option 3 treatment consists of Option 2 treatment with the addition of multi-media filtration technology. Option 3 treatment is also depicted in Figure 7-2.

Option 4 consists of solvent management for control of toxic organics. Solvent management is not a treatment system, but rather an in-plant control to collect used solvents for resale or contract disposal.

7.3.2 Luminescent Materials Subcategory

Option 1 treatment consists of neutralization for pH control.

Option 2 treatment consists of Option 1 treatment with the addition of: chemical preecipitation and clarification of all metals-bearing process wastes using lime, sodium carbonate, a coagulant and polyelectrolyte; and sludge dewatering. Option 2 is presented schematically in Figure 7-3.

7.4 ANALYSIS OF INDUSTRY PERFORMANCE DATA

The following subsections present data on the performance of in-place treatment systems in the Cathode Ray Tube and Luminescent Materials subcategories as they relate to the identified options presented in Section 7.3. Also presented are the results of analyses of available long-term effluent monitoring data and a discussion of the statistical methodology used to analyze the data.

7.4.1 Cathode Ray Tube Subcategory

Table 7-1 presents a summary (average influent and effluent concentrations) of the performance of Option 2 and Option 3 treatment technologies from results of the three-day samplings of color television picture tube manufacturing plants. Plant 30172 uses chromium reduction of concentrated chromium wastes and carbonate precipitation and settling of concentrated lead-bearing wastes. The effluents from these two treatment units are then

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combined with other process wastes and sent through a precipitation/clarification/filtration treatment system. The treatment system effluent is then combined with dilute process wastes and cooling water in a holding lagoon prior to direct discharge (see Figure 5-1). Within a primary tank, Plant 99796 performs chromium reduction on an acid waste that contains dissolved chromium. A concentrated lead bearing waste is periodically batch discharged to the primary tank for treatment. Overflow from the primary tank is combined with a caustic stream in a secondary tank and sent through a clarification system. The treatment system effluent enters a holding lagoon prior to indirect discharge (see Figure 5-3).

Also sampled was Plant 11114, a color television picture tube plant which has three separate treatment systems serving different areas of the plant (see Figure 5-2). The sampling results indicated that, although some components achieve pollutant reduction, wastewater treatment is generally ineffective at Plant 11114. For this reason, treatment performance data from this plant are not presented.

In addition to sampling data, long-term effluent self-monitoring data were submitted by three plants. Plant 30172 monitors the treatment system effluent following filtration. Plants 99797 and 99798 monitor the final effluents from their precipitation/clarification treatment systems.

Table 7-2 presents the results of statistical analyses of long-term data from the three plants. The derivation of the variability factors presented in Table 7-2 is discussed under statistical methodology in Section 7.4.3.

7.4.2 Luminescent Materials Subcategory

Table 7-3 presents a summary (average influent and effluent concentrations) of available Option 2 performance data for the Luminescent Materials subcategory. Both Plants 101 and 102 have combined treatment systems which treat wastes from many manufacturing operations. The treatment systems consist of flow equalization, precipitation, clarification and pH adjustment. Influent and effluent data were taken on three days of sampling conducted under this study.

7.4.3 Statistical Methodology

To establish effluent guideline limitations for the Electrical and Electronic Components Category, the available data were examined statistically to determine the performance levels that were attained by properly operated treatment systems in that industry. Two distinct sets of sampling data were available for this assessment. The first set consists of raw and effluent concentration data that were collected during sampling visits to representative plants in the industry. Typically, these data

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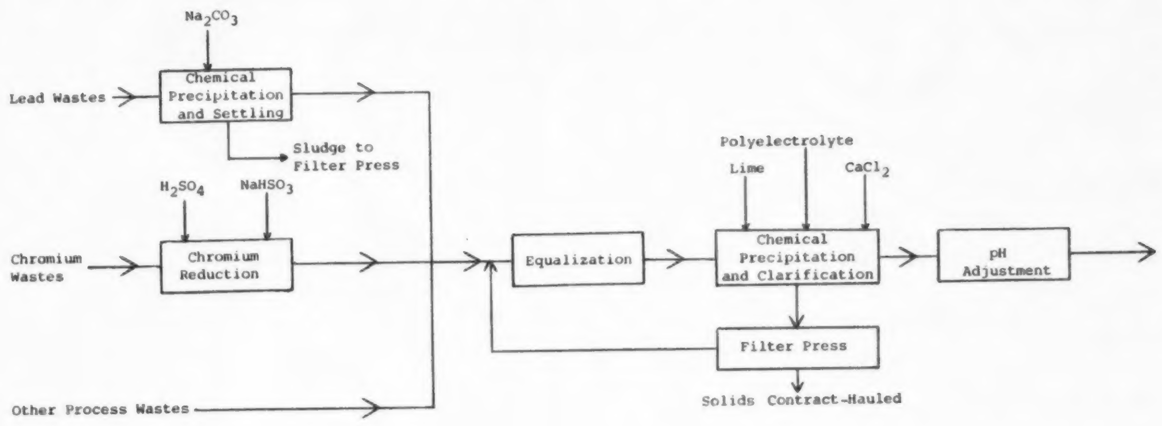
OPTION 2



OPTION 3

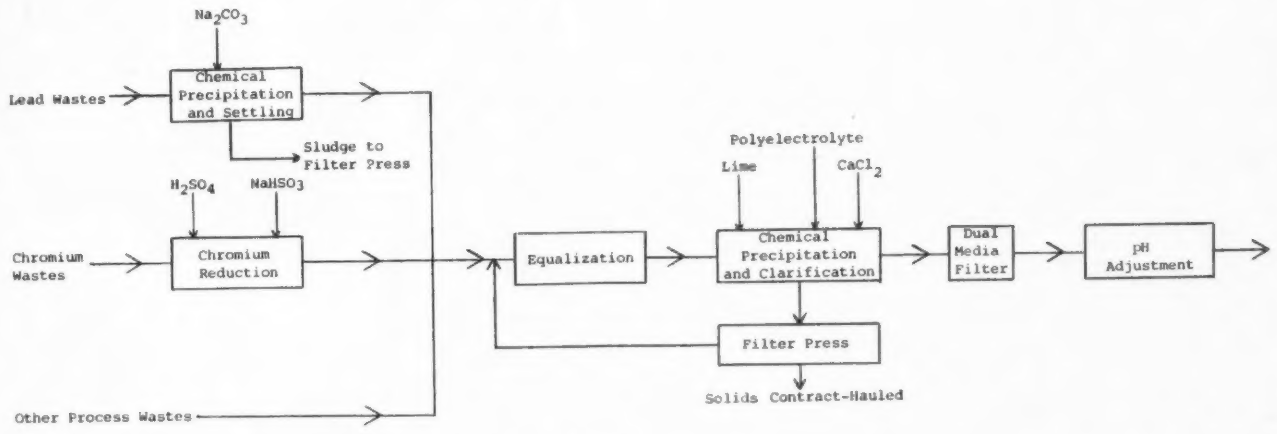


FIGURE 7-2

RECOMMENDED TREATMENT
CATHODE RAY TUBE SUBCATEGORY

OPTION 2

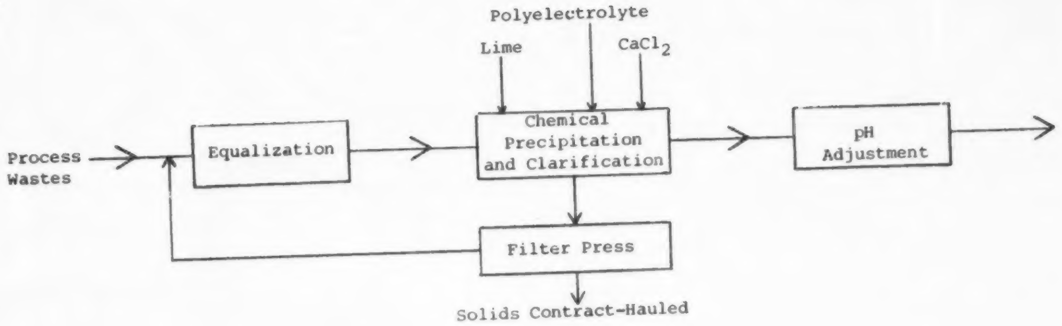


FIGURE 7-3

RECOMMENDED TREATMENT
LUMINESCENT MATERIALS SUBCATEGORY

TABLE 7-1

PERFORMANCE OF IN-PLACE TREATMENT

Parameter	Option 2 Treatment				Option 3 Treatment	
	Lead Waste Treatment		Precipitation/ Clarification		Dual-Media Filtration	
	Inf. (mg/l)	Eff. (mg/l)	Inf. (mg/l)	Eff. (mg/l)	Inf. (mg/l)	Eff. (mg/l)
PLANT 30172						
Toxic Metals						
Cadmium	1.070	<0.005	0.171	<0.002	<0.002	<0.002
Chromium	4.670	0.022	2.87	0.244	0.244	0.208
Lead	891	1.2	14.2	0.253	0.253	0.163
Zinc	1510	18.7	6.08	0.131	0.131	0.075
Other Pollutants						
TSS	190	11	89	2.5	2.5	3.1
Fluoride	160	78.5	340	7.1	7.1	11.1
PLANT 99796						
Toxic Metals						
Cadmium			0.063	0.019		
Chromium			0.990	0.163		
Lead			13.0	0.300		
Zinc			19.7	0.550		
Other Pollutants						
TSS			380	15		
Fluoride			31.7	30.00		

TABLE 7-2

STATISTICAL PARAMETERS FOR LONG-TERM EFFLUENT DATA

Parameter Plant No.	Number of Data Pts.	Milligrams per Liter Mean	Milligrams per Liter Std. Dev.	Coefficient of Variation	Variability Factor Daily	Variability Factor 22-day
Fluoride						
30172	18	16.08	4.06	0.252	1.59	1.09
99797	46	59.74	72.56	1.21	3.83	1.43
99798	9	12.06	1.16	0.096	1.22	1.03
Cadmium						
30172	18	0.015	0.007	0.435	2.42	1.15
99797	36	0.030	0.032	1.057	5.16	1.37
99798	9	0.015	0.006	0.403	2.29	1.14
Chromium						
30172	18*	0.808	0.978	1.211	5.81	1.42
99797	36	0.208	0.150	0.721	3.65	1.25
99798	9	0.244	0.224	0.918	4.54	1.32
Lead						
30172	18*	0.579	0.468	0.808	4.05	1.28
99797	47	0.587	0.457	0.778	3.91	1.27
99798	--					
Zinc						
30172	18*	0.262	0.333	1.27	6.05	1.45
99797	36	0.404	0.592	1.47	6.81	1.51
99798	9	0.262	0.162	0.616	3.19	1.22

*Data points represent average of two values.

TABLE 7-3

PERFORMANCE OF IN-PLACE TREATMENT

Luminescent Materials Subcategory
Option 2 Treatment

	Plant 101		Plant 102
Parameter	Influent mg/l	Effluent mg/l	Effluent mg/l
Toxic Metals			
Antimony	0.029	0.031	0.008
Cadmium	0.34	0.020	0.20
Zinc	5.52	0.42	0.47
Other Pollutants			
TSS	210	45	12

cover a period of 3 days of sampling. The other data consisted of sets of longer term self-monitoring data (usually effluent concentration only) that were submitted by plants in the Cathode Ray Tube subcategory. Analysis of the data for visited plants yielded mean effluent concentration values for each pollutant parameter (Tables 7-1 and 7-3). More information (than mean concentrations) is available from the longer term discharge monitoring data (Table 7-2) which allows a quantitative assessment of the variability of effluent concentrations following wastewater treatment. This data reflect the fact that even properly operating treatment systems experience fluctuations in pollutant concentrations discharged. These fluctuations result from variations in process flow, raw waste loading of pollutants, treatment chemical feed, mixing effectiveness during treatment, and combinations of these or other factors.

It has been found that the day-to-day variability in effluent concentrations includes occasional large changes while averages for each month's data experience smaller fluctuations. The variability in the monthly average is usually well described by the normal distribution as predicted by the Central Limit Theorem. However, daily fluctuations are most often described by a lognormal distribution. This reflects the fact that an effluent value may rise considerably from the mean level but may fall only to the value of zero. To quantify this variation in the effluent concentration of a pollutant, a daily and a monthly variability factor (a value always greater than 1.0) were derived from the self monitoring data. These factors were then multiplied by the mean pollutant concentration (derived from the visited plant data) to yield a daily and a monthly effluent limitation, respectively.

The following paragraphs describe the statistical methodology used to calculate the variability factors for pollutants of concern in the Cathode Ray Tube and Luminescent Materials subcategories and to establish limitations for pollutant concentrations.

CALCULATION OF VARIABILITY FACTORS

Variability factors are used to account for effluent concentration fluctuations in the establishment of reasonable effluent limitations. Calculation of these factors is discussed here, while their application is discussed under the next heading. A daily maximum variability factor and a monthly average variability factor were calculated for each pollutant parameter. The monthly average was calculated based on a 22-day month because these plants normally operate five days per week.

Daily Variability Factors--These calculations were based on the following three assumptions: (1) monitoring at each plant was conducted using standardized testing procedures such that the resulting measurements can be considered statistically

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independent and amenable to standard statistical procedures; (2) treatment facilities and monitoring techniques at each plant were substantially constant throughout the monitoring period; (3) the daily pollutant concentration data follow a distribution with characteristics that can be verified as lognormal or normal.

The first two assumptions, which concern self consistency of the data, were supported by direct examination of the data and by consideration of supplemental information accompanying the data.

In the cases of cadmium, chromium, lead and zinc, the distribution of daily data were verified as lognormal through the use of graphical plots and the Kolomogorov-Smirnov test for goodness of fit. Examples of these plots are shonw in Figures 7-4 through 7-7. A straight line plot confirms lognormal distribution of the data.

Once lognormality was verified, the daily maximum variability factor was calculated from the equation

$$\ln VF = 2.326(S') - 0.5\,(S')^2$$

In this equation, 2.326 is the Z value corresponding to the 99th percentile point for the distribution and S' is the estimated standard deviation of the natural logarithms of the concentrations. S' is calculated as the square root of ln (1.0 + (CV)ZQ2) where CV is the coefficient of variation.

In the case of fluoride, daily concentration data were better fit by a normal distribution. The normal distribution was verified by the use of graphical plots (See Figure 7-8) and the Kolomogorov-Smirnov test for goodness of fit.

Monthly Variability Factors--Since the monthly averages follow a normal distribution, the monthly variability factors for all pollutants were calculated from the equation

$$VF^* = 1.0 + 1.645\,(S/M)$$

In this equation, 1.645 is the Z value corresponding to the 99th percentile point for the distribution; S is the estimated standard deviation of the monthly average, obtained by dividing the standard deviation of the daily pollutant concentrations by the square root of22; and M is the mean value of the daily pollutant concentrations.

CALCULATION OF EFFLUENT LIMITATIONS

The effluent limitations are based on the premise that a plant's treatment system can be operated to maintain effluent concentrations equivalent to those concentrations observed at plants visited during the sampling program. As explained in the introduction, day-to-day concentrations will fluctuate below and above average concentrations. Thus an effluent limitation must be set far enough above the average concentration so that plants with properly operated treatment systems will not exceed the limit (99 percent of the time in the case of daily data, 95 percent of the time in the case of monthly averages).

Effluent limitations are obtained for each parameter by multiplying the average concentration (based on visit data) by the appropriate daily and monthly variability factors (based on historical data). Expressed as an equation

$$L = VF \times A$$

Where L is the effluent limitation, VF is the variability factor, and A is the Average concentration based on plant visit data.

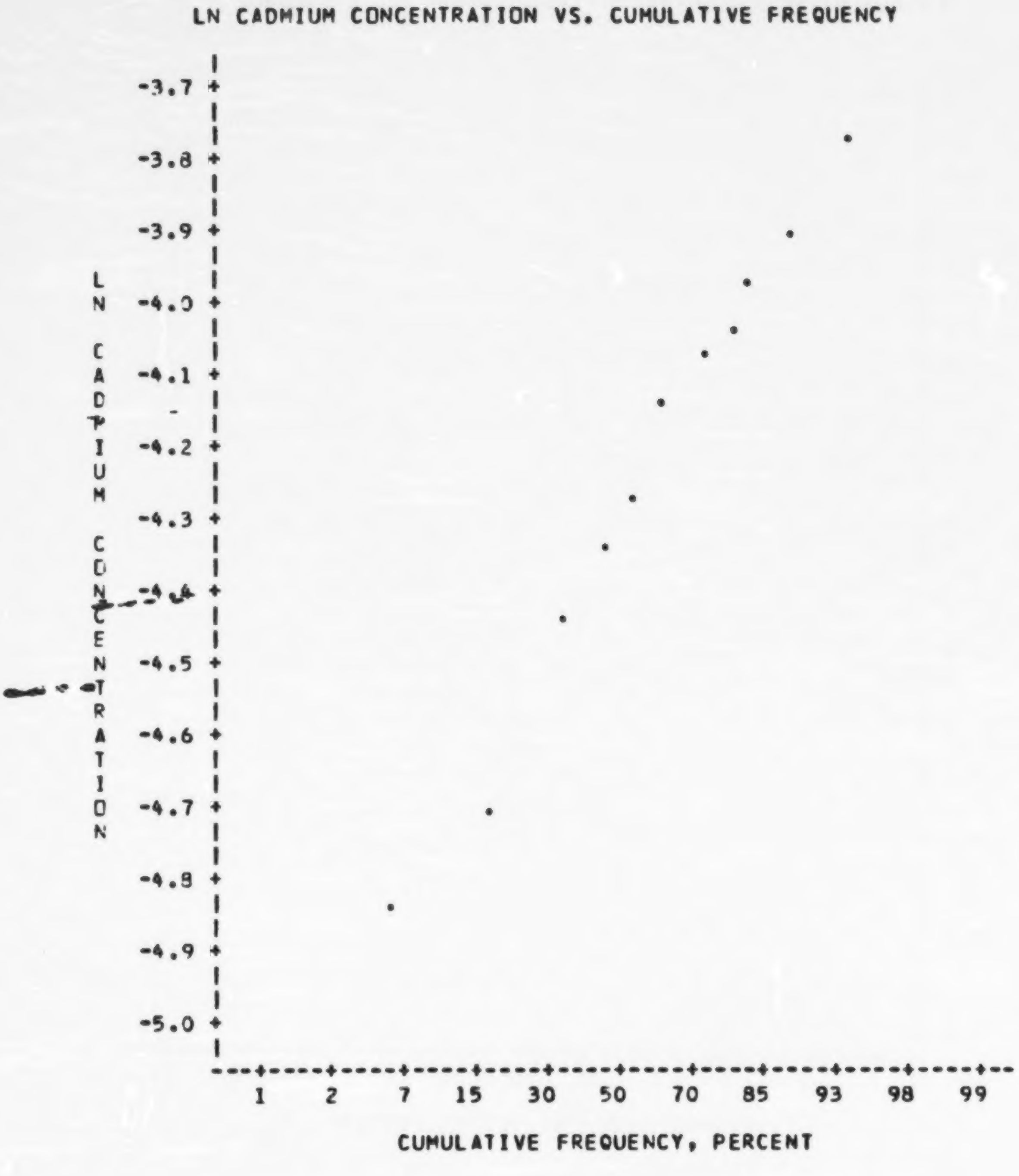

FIGURE 7-4

PLANT 30172

97<

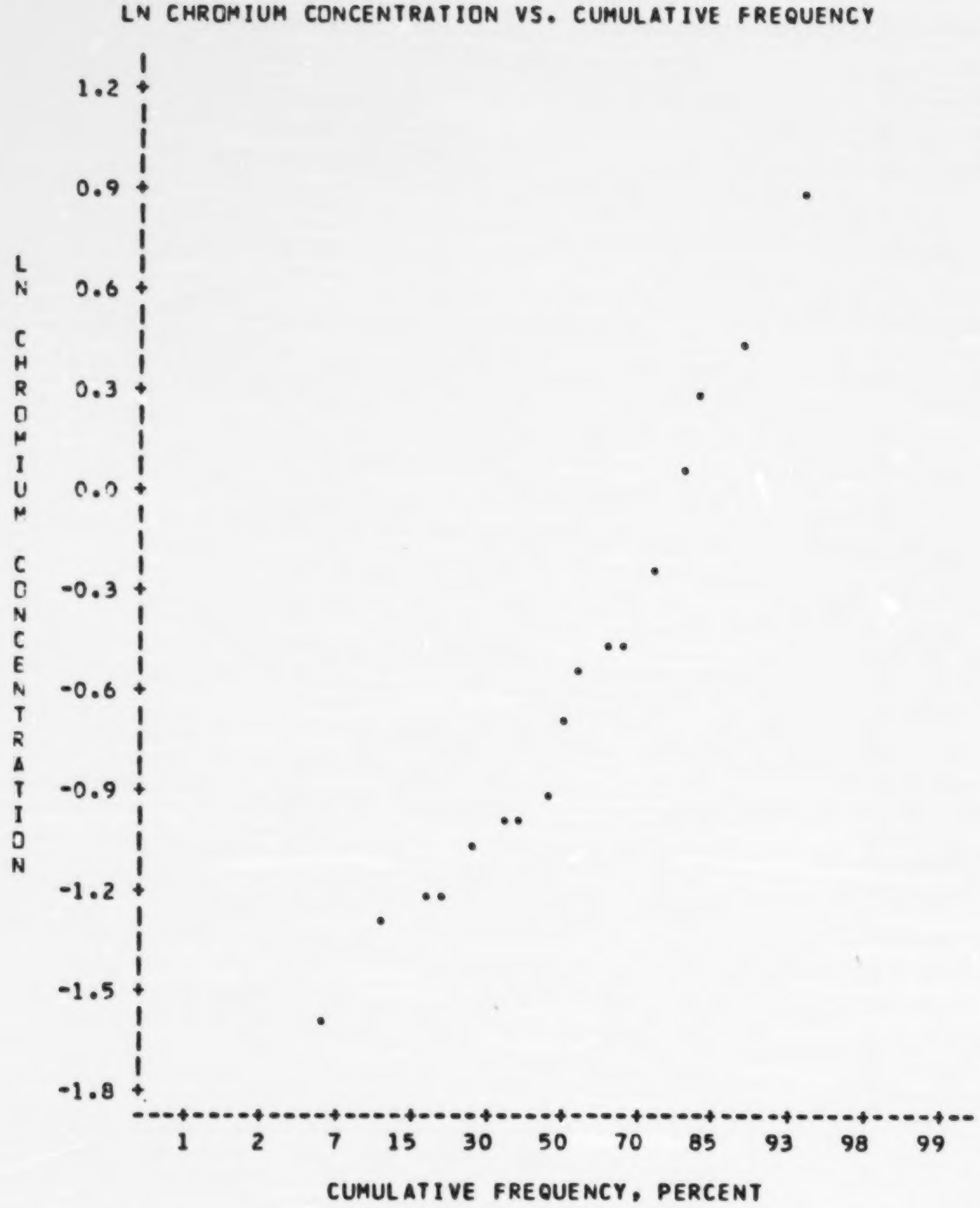

FIGURE 7-5

PLANT 30172

98<

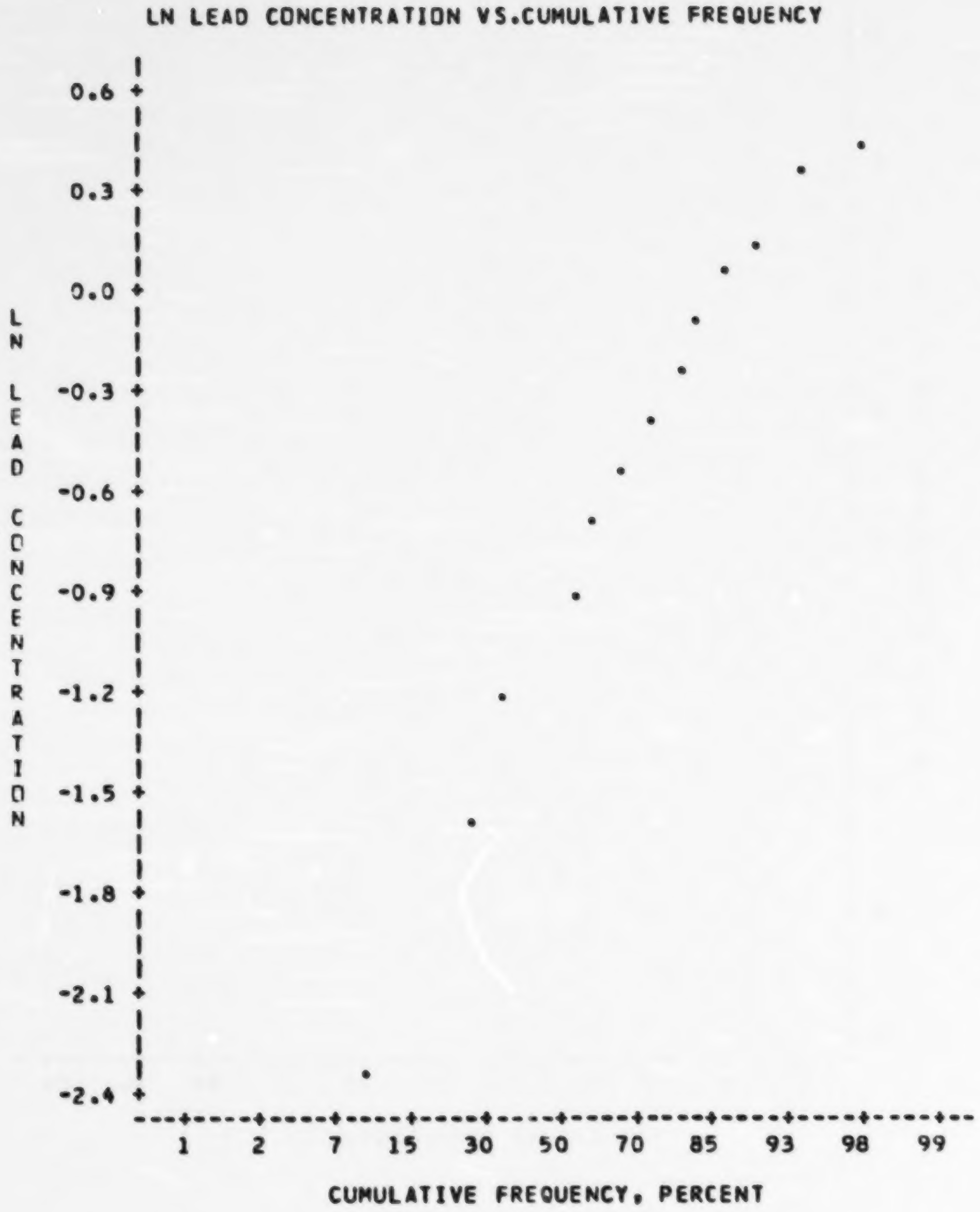

FIGURE 7-6

PLANT 99797

99<

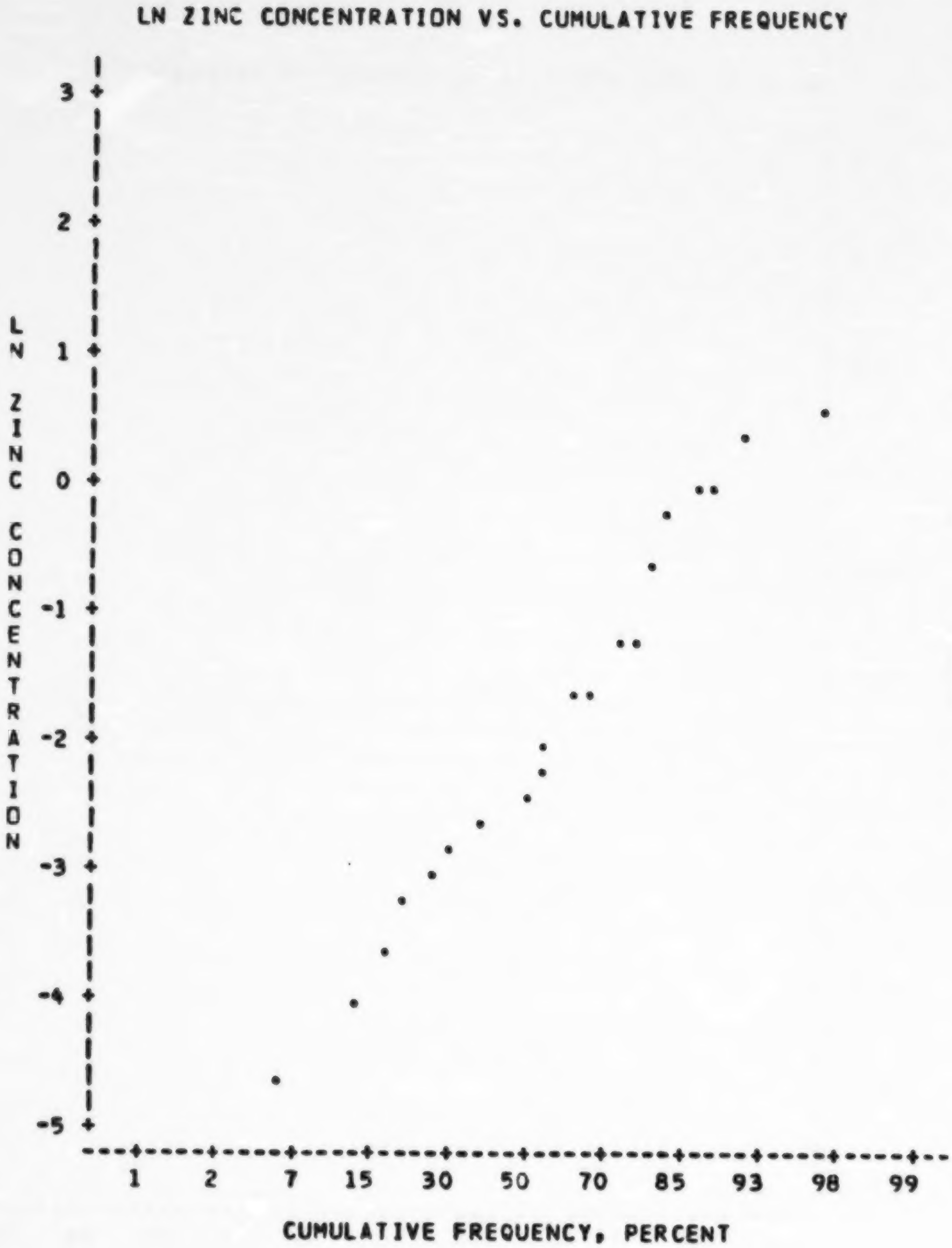

FIGURE 7-7

PLANT 99797

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FLUORIDE CONCENTRATION VS. CUMULATIVE FREQUENCY

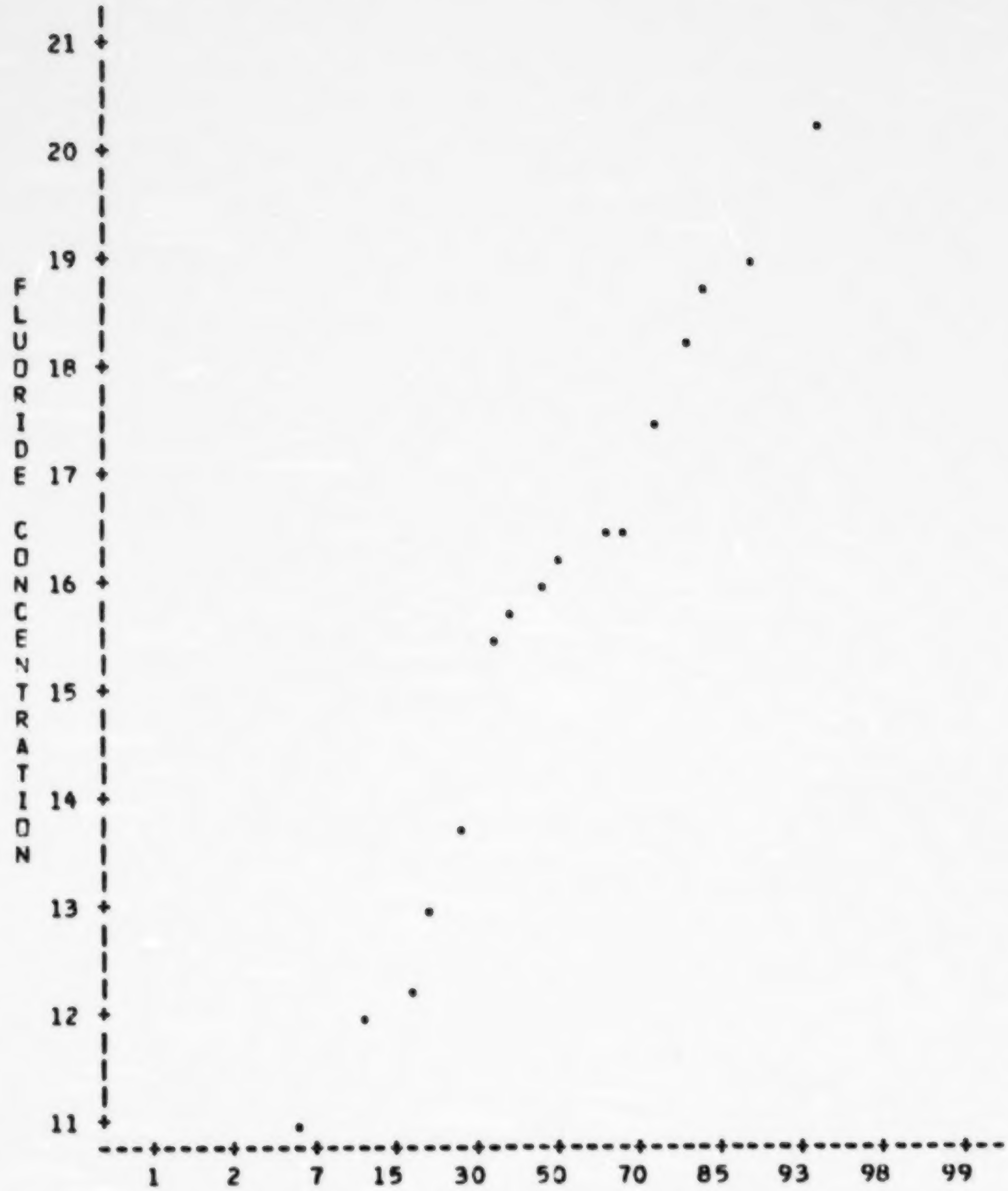

FIGURE 7-8

PLANT 30172

SECTION 8

SELECTION OF APPROPRIATE CONTROL AND TREATMENT TECHNOLOGIES AND BASES FOR LIMITATIONS

Proposed discharge regulations for the Cathode Ray Tube subcategory and the Luminescent Materials subcategory are presented in this section. The technology bases and the numerical bases are also presented for each regulation. The statistical methodology used to develop limitations was presented in Section 7.4.

8.1 CATHODE RAY TUBE SUBCATEGORY

The Agency is proposing not to regulate direct dischargers in the Cathode Ray Tube subcategory for reasons presented in Section 6.2. Therefore, BPT, BAT and BCT limitations are not being proposed.

8.1.1 Pretreatment Standards for Existing Sources (PSES)

Pollutant	Long Term Average (LTA) (mg/l)	Monthly Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
Cadmium	0.019	1.15	0.022	2.42	0.046
Chromium	0.20	1.32	0.26	4.54	0.91
Lead	0.28	1.28	0.36	4.05	1.13
Zinc	0.34	1.45	0.49	6.05	2.06
TTO			*		0.15
Fluoride	20.5	1.09	22.3	1.59	32.6

*The Agency is not proposing monthly limitations for reasons presented below.

EPA is proposing PSES based on Option 2 which consists of solvent management to control toxic organics, neutralization, and precipitation/clarification of the final effluent to reduce toxic metals and fluoride. Solvent management is widely practiced at cathode ray tube facilities as is neutralization. Precipitation/clarification technology is known to be currently practiced at nine CRT facilities. Option 1, neutralization, was not selected because it will not control toxic metals or fluoride. Option 3 was not selected because the demonstrated pollutant reduction beyond that achieved by Option 2 is considered insignificant. Precipitation/clarification technology achieves

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97-98 percent reduction of toxic metals, whereas filtration technology will only achieve an additional 0.6 percent reduction. If Option 3 was selected, the following limits would apply.

8.1.1 (Alternate) Pretreatment Standards for Existing Sources (PSES)

Pollutant	(LTA) (mg/l)	Monthly Average VF	Monthly Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Cadmium	0.019	1.15	0.022	2.42	0.046
Chromium	0.17	1.32	0.22	4.54	0.77
Lead	0.18	1.28	0.23	4.05	0.73
Zinc	0.195	1.45	0.28	6.05	1.18
TTO			*		0.15
Fluoride	20.5	1.09	22.3	1.59	32.6

Toxic Metals and Fluoride -- The proposed limitations for toxic metals (cadmium, chromium, lead and zinc) and fluoride are based on demonstrated performance at CRT plants employing precipitation/clarification treatment technologies. As described in Section 7, both on-site sampling and long-term effluent monitoring data are reflected in the limitations. They therefore incorporate both the plant-to-plant variations in raw wastes and treatment practices and the day-to-day variability of treatment system performance. The concentrations shown are all applicable to the treated effluent prior to any dilution with sanitary wastewater, noncontact cooling water, or other non-process water. The achievable long-term average concentrations used to develop the proposed limitations are based on sampling data presented in Table 7-1. The averages for chromium, lead, and zinc represent the average effluent concentrations following Option 2 treatment. The average for cadmium reflects the average effluent concentration at only one of the sampled plants since the other plant had uncharacteristically low cadmium levels in its effluent. The average for fluoride incorporates the filtered effluent fluoride concentration from Plant 30172 rather than the clarifier effluent concentration. Since the sampling data from this plant show increased fluoride levels following filtration, and since the fluoride levels are low, the data more likely reflect maximum performance for Option 2 technology.

The variability factors used to develop the proposed limitations are based on statistical analyses of long-term monitoring data submitted by three plants and summarized in Table 7-2. For cadmium, chromium, zinc, and fluoride, the median of three variability factors were selected. For lead, the higher of two variability factors were selected.

Total Toxic Organics (TTO) -- A daily maximum limit of 0.15 mg/l is being proposed. This limit reflects the highest concentration of TTO found at the sampled plants. Because only limited TTO data are available from the CRT industry, the Agency reviewed data from other industries, including other E&EC subcategories, to assess the reasonableness of this limitation. In the metal finishing industry, data indicate that precipitation/clarification technology reduces TTO by 80 percent. In the semiconductor subcategory, raw waste TTO levels at plants practicing good solvent management occur at from 0.03 to 1.4 milligrams per liter. Thus, if the CRT industry were to exhibit raw waste TTO levels within the range observed at semiconductor plants, reduction of TTO through Option 2 technology would result in effluent TTO levels near the proposed 0.15 milligram per liter limitation. The Agency has chosen not to establish a monthly average limitation primarily because solvent management is not a treatment technology and solvent management would not be expected to vary significantly from the daily maximum.

8.1.2 New Source Performance Standards (NSPS)

Pollutant	Long Term Average (LTA) (mg/l)	Monthly Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
Cadmium	0.019	1.15	0.022	2.42	0.046
Chromium	0.17	1.32	0.22	4.54	0.77
Lead	0.18	1.28	0.23	4.05	0.73
Zinc	0.195	1.45	0.28	6.05	1.18
TTO					0.15
Fluoride	20.5	1.09	22.3	1.59	32.6
TSS	12.8	1.26	16.1	3.35	42.9
pH	range from 6 to 9				

The Agency is proposing NSPS based on Option 3. This technology consists of neutralization and solvent management plus end-ofpipe precipitation/clarification followed by filtration. The addition of filtration is expected to further reduce toxic metals in the effluent over that expected from precipitation/clarification (Option 2). Because no significant reduction in fluoride or TTO is expected, the proposed limitations for these pollutants do not change from PSES.

Toxic Metals -- The basis for proposed limitations for the toxic metals is sampling data from one CRT facility practicing filtration of its final effluent. The percent reduction of each metal following filtration as calculated from Table 7.1 was applied to the long term average concentrations in PSES to develop the achievable long-term average. Variability factors are the same as those derived for Option 2 technology.

Total Suspended Solids (TSS) -- Proposed TSS limitations represent a transfer of technology from the Metal Finishing industrial category. The rationale for transferring technology from this industry is (1) the raw waste TSS concentrations are similar to those found in CRT wastes, and (2) the treatment technology used for solids reduction in the metal finishing industry is the same as that proposed for cathode ray tubes.

The average effluent concentration of 12.8 milligrams per liter was derived from EPA sampling data from several metal finishing plants practicing solids removal by clarification and filtration technology. Excluded from the data base were plants with improperly operated treatment systems. The variability factors of 1.26 and 3.35 each represent the median of variability factors from 17 metal finishing plants with long-term monitoring data.

pH -- Properly operated end-of-pipe neutralization of wastewater will ensure discharges in the pH range of 6 to 9.

8.1.3 Pretreatment Standards for New Sources (PSNS)

Pollutant	Long Term Average (LTA) (mg/l)	Monthly Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
Cadmium	0.019	1.15	0.022	2.42	0.046
Chromium	0.17	1.32	0.22	4.54	0.77
Lead	0.18	1.28	0.23	4.05	0.73
Zinc	0.195	1.45	0.28	6.05	1.18
TTO					0.15
Fluoride	20.5	1.09	22.3	1.59	32.6

The Agency is proposing PSNS based on Option 3. This technology consists of neutralization and solvent management plus end-ofpipe precipitation/clarification followed by filtration. As with NSPS the addition of filtration is expected to further reduce toxic metals in the effluent over that expected from precipitation/clarification (Option 2), but no significant reduction in fluoride or TTO is expected.

The basis for the toxic metals, total toxic organics (TTO) and fluoride limitations were presented under NSPS. These limitations do not change for PSNS.

8.2 LUMINESCENT MATERIALS SUBCATEGORY

The Agency is proposing not to regulate existing dischargers in the Luminescent Materials subcategory for reasons presented in Section 6.2.

8.2.1 New Source Performance Standards (NSPS)

Pollutant	Long Term Average (LTA) (mg/l)	Monthly Average VF	Monthly Average Limit (mg/l)	Daily Maximum VF	Daily Maximum Limit (mg/l)
Cadmium	0.20	1.15	0.23	2.42	0.48
Antimony	0.03	1.45	0.044	6.05	0.18
Zinc	0.47	1.45	0.68	6.05	2.84
Fluoride	20.5	1.09	22.3	1.59	32.6
TSS	18.2	1.26	22.9	3.35	61.0
pH	range from 6-9				

EPA is proposing NSPS based on Option 2 technology which consists of precipitation/clarification and neutralization. This technology controls pH, total suspended solids (TSS), fluoride, cadmium, antimony, and zinc. All but one of the dischargers in the Luminescent Materials subcategory are currently practicing this technology. Option 1 was not selected because it will not control toxic metals and fluoride.

The bases for pH and fluoride limitations were presented in Section 8.1 for cathode ray tubes. The proposed limitations for these pollutants are the same for luminescent materials. The bases for toxic metals and suspended solids limitations are presented below.

Toxic Metals -- The proposed NSPS limitations for toxic metals (cadmium, antimony and zinc) are based on sampling data from two luminescent materials plants employing precipitation/clarification technologies. Because the available data are limited, the higher value of each toxic metal from the two plants was selected as the achievable long-term average. Variability factors for cadmium and zinc are the same as those derived for the CRT industry, which practices the same treatment technology. These variability factors are discussed in Section 8.1.1.

Because no long-term monitoring data were available for antimony, the higher of the variability factors for the other metals, those for zinc, were applied for antimony.

Total Suspended Solids (TSS) -- Proposed TSS limitations represent a transfer of technology from the Metal Finishing industrial category. The rationale for transferring technology from this industry is (1) the raw waste TSS concentrations are similar to those found in luminescent materials wastes, and (2) the treatment technology used for solids reduction in the metal finishing industry is the same as that proposed for luminescent materials.

The average concentration of 18.2 milligrams per liter was derived from EPA sampling data from numerous metal finishing practicing solids removal by clarification technology. Excluded from the data base were plants with improperly operated treatment systems. The variability factors each represent the median of variability factors from 17 metal finishing plants with long-term monitoring data.

8.2.2 Pretreatment Standards for New Sources (PSNS)

Pollutant	Long Term Average (LTA) (mg/l)	Monthly Average		Daily Maximum	
		VF	Limit (mg/l)	VF	Limit (mg/l)
Cadmium	0.20	1.15	0.23	2.42	0.48
Antimony	0.03	1.45	0.044	6.05	0.18
Zinc	0.47	1.45	0.68	6.05	2.84
Fluoride	20.5	1.09	22.3	1.59	32.6

For PSES, the Agency is proposing limitations based on Option 2, neutralization and end-of-pipe precipitation/clarification for control of toxic metals and fluoride. Option 1 was not selected because it will not control toxic metals or fluoride.

Proposed PSNS limitations for luminescent materials producers are the same as those proposed for NSPS except that pH and TSS are not regulated for pretreatment. The basis for limitations were presented in Section 8.2.1.

SECTION 9

COST OF WASTEWATER TREATMENT AND CONTROL

This section presents estimates of the costs of implementation of wastewater treatment and control systems for the Cathode Ray Tube and Luminescent Materials subcategories of the Electrical and Electronic Components category. The systems for which cost estimates are presented are those options identified in Section 7. The cost estimates then provide the basis for possible economic impact of regulation on the industry. The general approach or methodology for cost estimating is presented below followed by the treatment and control costs.

9.1 COST ESTIMATING METHODOLOGY

Costs involved in setting up and operating a wastewater treatment unit are comprised of investment costs for construction, equipment, engineering design, and land, and operating costs for energy, labor, and chemicals. There are also costs for disposing of sludge and for routine analysis of the treated effluent.

The costs presented in this section are based on model plants which closely resemble the types and capacities of waste treatment facilities needed for each product subcategory. Model plants are not set up as exemplary plants, but as typical of sufficient design to represent the range of plants and treatment facilities present in the industry. Data are based on plant visits and contacts with industries to verify treatment practices and to obtain data on size, wastewater flow, and solid waste disposal systems. The differences in treatment capacities are reflected in the choice of model plants which are presented for different flow rates covering the existing range of flows at average concentrations of pollutants.

Unit process equipment costs were assembled from vendors and other commercial sources. Information on the costs of equipment, the present costs of chemicals and average costs for hauling sludge was developed with data from industry, engineering firms, and equipment suppliers. Appropriate factors were applied to determine total investment costs and annual costs.

The costs which will actually be incurred by an individual plant may be more or less than presented in the cost estimate. The major variations in treatment costs between plants result from differences in pollutant concentrations and site dependent conditions, as reflected in piping lengths, climate, land availability, water and power supply and the location of the point of final discharge. In addition, solids disposal costs and material costs will vary depending on geographical locations.

The following assumptions were employed in the cost development:

1. All non-contact cooling water was excluded from treatment and treatment costs.
2. Source water treatment, cooling tower and boiler blowdown discharges were not considered process wastewater.
3. Sanitary sewage flow is excluded.
4. The treatment facilities were assumed to operate 24-hours per day five days per week.
5. Excluded from the estimates were any costs associated with permits, reports or hearings required by regulatory agencies.

Investment costs are expressed in mid-year 1982 dollars to construct facilities at various wastewater flow rates. Operation, maintenance, and amortization of the investment are expressed as base level annual costs.

9.1.1 Direct Investment Costs for Land and Facilities

Types of direct investment costs for waste treatment facilities and criteria for estimating major components of the model plants are presented below.

Construction Costs -- Construction costs include site preparation, grading, enclosures, buildings, foundations, earthworks, roads, paving, and concrete. Since few if any buildings will be utilized, construction costs have been calculated using a factor of 1.15 applied to the installed equipment cost.

Equipment Cost -- Equipment for wastewater treatment consists of a combination of items such as pumps, chemical feed systems, agitators, flocculant feed systems, tanks, clarifiers and thickeners. Cost tables for these items were developed from vendor's quotations for a range of sizes, capacities and motor horsepowers. Except for large size tanks and chemical storage bins, the cost represents packaged, factory-assembled units.

Critical equipment is assumed to be installed in a weatherproof structure. Chemical storage feeders and feedback controls include such items as probes, transmitters, valves, dust filters and accessories. Critical pumps are furnished in duplicate as a duty and a spare, each capable of handling the entire flow.

Installation Costs (included in equipment-in-place costs) -- Installation is defined to include all services, activities, and miscellaneous material necessary to implement the described wastewater treatment and control system, including piping, fittings, and electrical work. Many factors can impact the cost of installing equipment modules. These include wage rates, manpower availability, who does the job (outside contractor or regular employees), new construction versus modification of existing systems, and site-dependent conditions (e.g., the availability of sufficient electrical service). In these estimates, installation costs were chosen for each model based upon average site conditions taking into consideration the complexity of the system being installed. An appropriate cost is allowed for interconnecting piping, power circuits and controls.

Monitoring Equipment -- It is assumed that monitoring equipment will be installed at the treated effluent discharge point. It will consist of an indicating, integrating, and recording type flow meter, pH meter, sensor, recorder, alarms, controls and an automatic sampler.

Land -- Land availability and cost of land can vary significantly, depending upon geographical location, degree of urbanization and the nature of adjacent development. Land for waste treatment is assumed to be contiguous with the production plant site. For the purpose of the report land is valued at $24,000 per acre.

Investment Costs for Supporting Services -- Engineering design and inspection are typical services necessary to advance a project from a concept to an operating system. Such services broadly include laboratory and pilot plant work to establish design parameters, site surveys to fix elevation and plant layout, foundation and groundwater investigation, and operating instructions, in addition to design plans, specifications and inspection during construction. These costs, which vary with job conditions, are often estimated as percentages of construction costs, with typical ranges as follow:

Preliminary survey and construction surveying	1 to 2 %
Soils and groundwater investigation	1 to 2 %
Laboratory and pilot process work	2 to 4 %
Engineering design and specifications	7 to 12%
Inspection during construction	2 to 3 %
Operation and maintenance manual	1 to 3 %

From these totals of 14 to 26 percent, a value of 17 percent of equipment cost has been used in this study to represent the engineering and design cost applied to model plant cost estimates.

The Contractor's Fee and Contingency -- These costs are usually expressed as a percentage of in-place construction cost, includes such general items as temporary utilities, small tools, field office overhead and administrative expense. The contractor is entitled to a reasonable profit on his activities and to the cost of interest on capital tied up during construction. Although not all of the above cost will be incurred on every job, an additional 50 percent of the in-place construction cost has been used to cover related cost broadly described as contractor's fees, incidentals, overhead, and contingencies.

9.1.2 Annual Costs

Operation and Maintenance Costs -- Annual operation and maintenance costs are described and calculated as follows:

Labor and Supervision Costs:

Personnel costs are based on an hourly rate of $20.00. This includes fringe benefits and an allocated portion of costs for management, administration and supervision. Personnel are assigned for specific activities as required by the complexity of the system, ranging from 1-8 hours per day.

Energy Costs:

Energy costs are based on the cost of $306.00 per horsepower operating 24 hours per day and 350 days per year. For batch processes appropriate adjustments were made to suit the production schedule. The cost per horsepower year is computed as follows:

$$Cy = 1.1\ (0.745\ HP \times Hr. \times Ckw)/(E \times P)$$

where Cy = Cost per year
HP = Total Horsepower Rating of Motor (1 HP = 0.7457 kw)
E = Efficiency Factor (0.9)
P = Power Factor (1.00)
Hr. = Annual Operating Hours (350 x 24 = 8400)
Ckw = Cost per Kilowatt-Hour of Electricity ($0.040)

Note: The 1.1 factor in the equation represents allowance for incidental energy used such as lighting, etc. It is assumed that no other forms of energy are used in the waste treatment system.

Chemicals:

Prices for the chemicals were obtained from vendors and the Chemical Marketing Reporter. Unit costs of common chemicals delivered to the plant site are based on commercial grade of the strength or active ingredient percentage with prices as follows:

Lime (Calcium Hydroxide) Bulk	$54/Ton
Sulfuric Acid	$84/Ton
Flocculant	$ 2/Lb

Sodium Bisulfite	$0.32/Lb
Soda Ash	$0.14/Lb
Calcium Chloride	$0.24/Lb

Maintenance:

The annual cost of maintenance is estimated as ten percent (10%) of the investment cost, excluding land.

Taxes and Insurance:

An annual provision of three percent of the total investment cost has been included for taxes and insurance.

Residual Waste Disposal:

Sludge disposal costs can vary widely. Chief cost determinants include the amount and type of waste. Off-site hauling and disposal costs are taken as $50/ton for bulk hauling, with appropriate increases for small quantities in steel containers. Information available to the Agency indicates that the selected technologies for controlling pollutants in this industry will not result in hazardous wastes as defined by RCRA.

Monitoring, Analysis and Reporting:

The manpower requirements covered by the annual labor and supervision costs include those activities associated with the operation and maintenance of monitoring instruments, recorder and automatic samplers as well as the taking of periodic grab samples. Additional costs for analytical laboratory services have been estimated for each subcategory assuming that sampling takes place three times a week at the point of discharge. A cost of $7500/year has been used for monitoring analyses and reporting.

Amortization:

Amortization of capital costs (investment costs) are computed as follows:

$$CA = B\ (r(1+r)ZQn)/((1+r)ZQn - 1)$$

where CA = Annual Cost
B = Initial amount invested excluding cost of land
r = Annual interest rate (assumed 13 percent)
n = Useful life in years

The multiplier for B in equation (1) is often referred to as the capital recovery factor and is 0.2843 for the assumed overall useful life of 5 years. No residual or sludge value is assumed.

9.1.3 Items not Included in Cost Estimate

Although specific plants may encounter extremes of climate, flood hazards and lack of water, the cost of model plants have been estimated for average conditions of temperature, drainage and natural resources. It is assumed that any necessary site drainage, roads, water development, security, environmental studies and permit costs are already included in production facilities costss. Therefore, the model costs are only for facilities, suppliers and services directly related to the treatment and disposal of waterborne wastes, including land needed for treatment and on-site sludge disposal. Air pollution control equipment is not included, except for dust collectors associated with treatment, chemical transfer and feeding. Raw wastes from various sources are assumed to be delivered to the treatment facility at sufficient head to fill the influent equalization basin, and final effluent is discharged by gravity. Cost of pumps, pipes, lines etc., necessary to deliver raw wastewater to the treatment plant or to deliver the treated effluent to the point of discharge are not included in the cost estimates.

9.2 COST ESTIMATES FOR TREATMENT AND CONTROL OPTIONS

9.2.1 Cathode Ray Tube Subcategory

Option 1 treatment is defined as neutralization for pH control. Minimal, if any, costs are associated with this option. All plants in the data base currently practice neutralization of their effluent.

Option 2 treatment is defined as Option 1 treatment with the addition of: chromium reduction; chemical precipitation and clarification of all metals-bearing wastes; and sludge dewatering. The capital and annual costs for this option are presented in Table 9-1. The range of model plant wastewater flows reflects the range of flows that currently exist in the subcategory. Figure 9-1 graphically presents the annual costs versus plant wastewater flow for this option.

Option 3 capital and annual costs for adding multi-media filtration to Option 2 treatment are presented in Table 9-2. Figure 9-2 graphically presents the annual costs versus plant wastewater flow for this option. The costs are incremental and therefore only reflect the additional costs of adding filtration technology end-of-pipe.

Option 4 is defined as solvent management, segregation and collection of solvents for resale or contractor disposal. The

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collection of waste solvents for resale or disposal is widely practiced in this industry.

9.2.2 Luminescent Materials Subcategory

Option 1 treatment is defined as neutralization for pH control. This option is currently practiced by both direct dischargers. Therefore no costs are associated with this option.

Option 2 treatment is defined as Option 1 treatment with the addition of chemical precipitation and clarification of all metals-bearing wastes, and sludge dewatering. All but one luminescent materials manufacturing plant are currently practicing Option 2 technology or its equivalent. Model plant costs for this option were therefore not developed. The costs to install Option 2 treatment at the one facility were developed specifically for that 25,000 gpd plant. The capital investment cost is $93,400; the annual cost is $57,500.

Option 3 capital and annual costs for adding filtration to Option 2 treatment are presented in Table 9-2 and Figure 9-2. These model costs are the same as the costs developed for the Cathode Ray Tube subcategory.

9.3 ENERGY AND NON-WATER QUALITY ASPECTS

Compliance with the proposed regulations will have no effect on air, noise, or radiation pollution and will only result in minimal energy usage. The amount of solid waste generated will be approximately 1200 metric tons per year. It has not been determined whether the solid wastes generated at CRT and luminescent materials manufacturing plants are hazardous as defined in the Resource Conservation and Recovery Act (RCRA). However, it is believed that further testing will find the waste to be nonhazardous. Energy requirements associated with these regulations will be 24,000 kilowatt-hours per year or only 6.4 kilowatt-hours per day per facility. Based on the above non-water quality impacts from these regulations, EPA has concluded that the proposed regulations best serve overall national environmental goals.

TABLE 9-1

OPTION 2 TREATMENT COSTS

FLOW	10,000 GPD	50,000 GPD	100,000 GPD
A. INVESTMENT COSTS			
Construction........	7,080	15,000	37,000
Equipment in place including piping, fittings, electrical work and controls...	78,588	170,000	410,000
Monitoring equipment in place............	6,000	6,000	6,000
Engineering Design and inspection......	2,950	11,000	26,500
Incidentals, overhead, fees, contigencies..	4,720	92,000	205,000
Land.................	6,000	6,000	6,000
TOTAL INVESTMENT COST	105,338	300,000	690,500
B. OPERATION AND MAINTENANCE COST			
Labor and supervision	10,000	25,000	30,000
Energy..............	180	900	1,900
Chemicals...........	1,220	6,000	12,800
Maintenance.........	9,950	29,000	68,450
Taxes and insurance.	3,160	9,000	20,850
Residual waste disposal............	1,550	5,000	11,000
Monitoring, analysis and reporting.......	7,500	7,500	7,500
TOTAL OPERATION AND MAINTENANCE COST	33,560	82,400	183,800
C. AMORTIZATION OF INVESTMENT COST	28,240	83,600	194,600
TOTAL ANNUAL COST	61,800	166,000	378,400

TABLE 9-1 continued

OPTION 2 TREATMENT COSTS

FLOW	200,000 GPD	500,000 GPD
A. INVESTMENT COSTS		
Construction........	61,000	82,000
Equipment in place including piping, fittings, electrical work and controls...	680,000	915,000
Monitoring equipment in place............	6,000	6,000
Engineering Design and inspection......	43,000	60,000
Incidentals, overhead, fees, contigencies..	370,000	498,000
Land.................	6,000	6,000
TOTAL INVESTMENT COST	1,166,000	1,567,000
B. OPERATION AND MAINTENANCE COST		
Labor and supervision	40,000	40,000
Energy..............	3,000	9,000
Chemicals...........	24,000	60,000
Maintenance.........	116,000	156,000
Taxes and insurance.	35,000	47,000
Residual waste disposal...........	22,000	58,000
Monitoring, analysis and reporting.......	7,500	7,500
TOTAL OPERATION AND MAINTENANCE COST	247,500	377,500
C. AMORTIZATION OF INVESTMENT COST	331,500	445,500
TOTAL ANNUAL COST	579,000	823,000

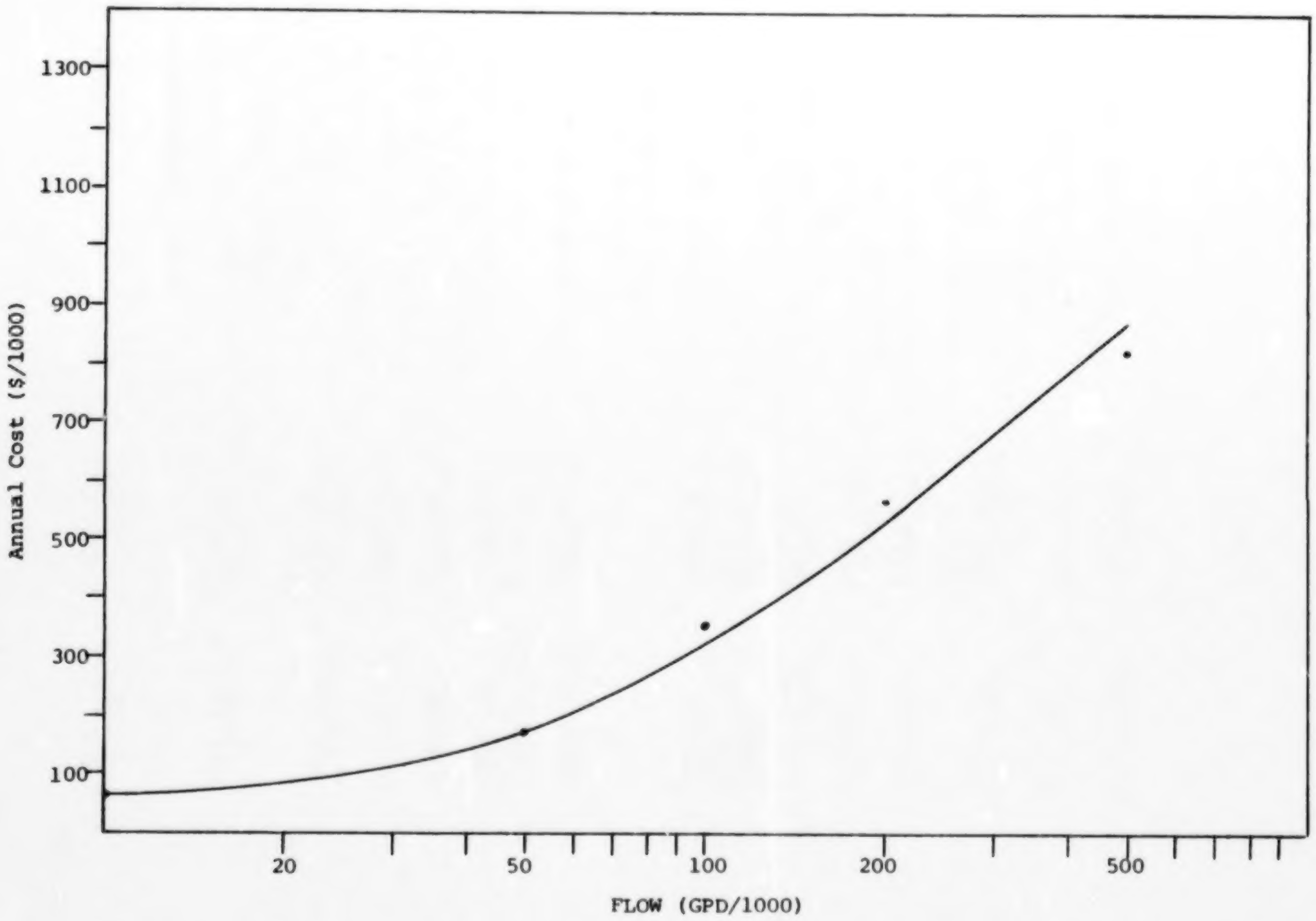

FIGURE 9-1
Annual Cost vs. Flow for
Option 2 Technology

TABLE 9-2

OPTION 3 TREATMENT COSTS

FLOW	10,000 GPD	50,000 GPD	100,000 GPD
A. INVESTMENT COSTS			
Construction........	400	1,000	4,000
Equipment in place including piping, fittings, electrical work and controls...	4,500	7,000	26,250
Monitoring equipment in place............	-	-	-
Engineering Design and inspection......	-	-	-
Incidentals, overhead, fees, contigencies..	270	4,000	13,000
Land.................	-	-	-
TOTAL INVESTMENT COST	5,170	12,000	43,250
B. OPERATION AND MAINTENANCE COST			
Labor and supervision	-	-	-
Energy..............	-	-	-
Chemicals...........	-	-	-
Maintenance.........	500	1,200	4,300
Taxes and insurance.	150	400	1,300
Residual waste disposal............	-	-	-
Monitoring, analysis and reporting.......	-	-	-
TOTAL OPERATION AND MAINTENANCE COST	650	1,600	5,600
C. AMORTIZATION OF INVESTMENT COST	1,470	3,500	12,300
TOTAL ANNUAL COST	2,120	5,100	17,900

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TABLE 9-2 continued

OPTION 3 TREATMENT COSTS

FLOW	200,000 GPD	500,000 GPD
A. INVESTMENT COSTS		
Construction........	7,000	14,000
Equipment in place including piping, fittings, electrical work and controls...	48,000	96,000
Monitoring equipment in place...........	-	-
Engineering Design and inspection......	-	-
Incidentals, overhead, fees, contigencies..	27,500	55,000
Land................	-	-
TOTAL INVESTMENT COST	82,500	165,000
B. OPERATION AND MAINTENANCE COST		
Labor and supervision	-	-
Energy.............	-	-
Chemicals..........	-	-
Maintenance.........	8,300	16,500
Taxes and insurance.	2,500	5,000
Residual waste disposal...........	-	-
Monitoring, analysis and reporting.......	-	-
TOTAL OPERATION AND MAINTENANCE COST	10,800	21,500
C. AMORTIZATION OF INVESTMENT COST	23,500	47,000
TOTAL ANNUAL COST	34,300	68,500

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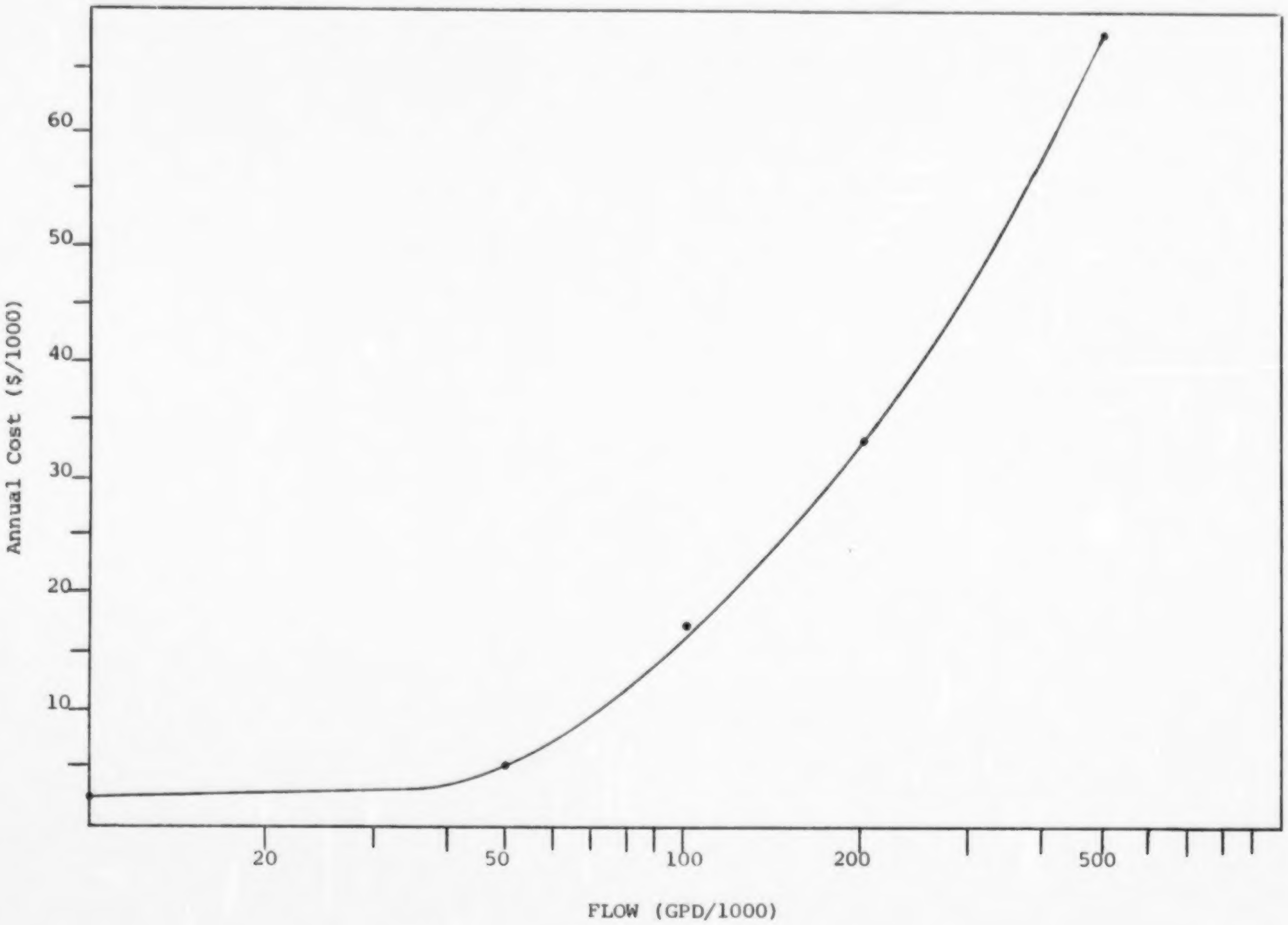

FIGURE 9-2
Annual Cost vs. Flow for
Option 3 Technology

SECTION 10

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SECTION 11

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SECTION 12

GLOSSARY

Absorb - To take up matter or radiation.

Act - Federal Water Pollution Control Act.

Activate - To treat the cathode or target of an electron tube in order to create or increase the emission of electrons.

Adjustable Capacitor - A device capable of holding an electrical charge at any one of several discrete values.

Adsorption - The adhesion of an extremely thin layer of molecules (of gas, liquid) to the surface of solids (granular activated carbon for instance) or liquids with which they are in contact.

Aging - Storage of a permanent magnet, capacitor, meter or other device (sometimes with a voltage applied) until the characteristics of the device become essentially constant.

Algicide - Chemicals used to retard the growth of phytoplankton (algae) in bodies of water.

Aluminum Foil - Aluminum in the form of a sheet of thickness not exceeding 0.005 inch.

Anneal - To treat a metal, alloy, or glass by a process of heating and slow cooling in order to remove internal stresses and to make the material less brittle.

Anode - The collector of electrons in an electron tube. Also known as plate; positive electrode.

Anodizing - An electrochemical process of controlled aluminum oxidation producing a hard, transparent oxide up to several mils in thickness.

Assembly or Mechanical Attachment - The fitting together of previously manufactured parts or components into a complete machine, unit of a machine, or structure.

Autotransformer - A power transformer having one continuous winding that is tapped; part of the winding serves as the primary coil and all of it serves as the secondary coil, or vice versa.

Ballast - A circuit element that serves to limit an electric current or to provide a starting voltage, as in certain types of lamps, such as in fluorescent ceiling fixtures.

Binder - A material used to promote cohesion between particles of carbon or graphite to produce solid carbon and graphite rods or pieces.

Biochemical Oxygen Demand - (1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) Standard test used in assessing wastewater quality.

Biodegradable - The part of organic matter which can be oxidized by bioprocesses, e.g., biodegradable detergents, food wastes, animal manure, etc.

Biological Wastewater Treatment - Forms of wastewater treatment in which bacteria or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present. Intermittent sand filters, contact beds, trickling filters, and activated sludge processes are examples.

Breakdown Voltage - Voltage at which a discharge occurs between two electrodes.

Bulb - The glass envelope which incloses an incandescent lamp or an electronic tube.

Busbar - A heavy rigid, metallic conductor, usually uninsulated, used to carry a large current or to make a common connection between several curcuits.

Bushing - An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier (conducting or otherwise), for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

Calcining - To heat to a high temperature without melting or fusing, as to heat unformed ceramic materials in a kiln, or to heat ores, precipitates, concentrates or residues so that hydrates, carbonates or other compounds are decomposed and volatile material is expelled, e.g., to heat limestone to make lime.

Calibration - The determination, checking, or correction of the graduation of any instrument giving quantitative measurements.

Capacitance - The ratio of the charge on one of the plates of a capacitor to the potential difference between the plates.

Capacitor - An electrical circuit element used to store charge temporarily, consisting in general of two conducting materials separated by a dielectric materials.

Carbon - A nonmetallic, chiefly tetravalent element found native or as a constituent of coal, petroleum, asphalt, limestone, etc.

Cathode - The primary source of electrons in an electron tube; in directly heated tubes the filament is the cathode, and in indirectly heated tubes a coated metal cathode surrounds a heater.

Cathode Ray Tube - Anelectron-beam tube in which the beam can be focussed to a small crosss section on a luminescent screen and varied in position and intensity to produce a visible pattern.

Central Treatment Facility - Treatment plant which co-treats process wastewaters from more than one manufacturing operation or co-treats process wastewaters with noncontact cooling water or with non-process wastewaters (e.g., utility blow-down, miscellaneous runoff, etc.).

Centrifuge - The removal of water in a sludge and water slurry by introducing the water and sludge slurry into a centrifuge. The sludge is driven outward with the water remaining near the center. The dewatered sludge is usually landfilled.

Ceramic - A product made by the baking or firing of a nonmetallic mineral such as tile, cement, plaster, refractories, and brick.

Chemical Coagulation - The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.

Chemical Oxidation - The addition of chemical agents to wastewater for the purpose of oxidizing pollutant material, e.g., removal of cyanide.

Chemical Oxygen Demand (COD) - (1) A test based on the fact that all organic compounds, with few exceptions, can be oxidized to carbon dioxide and water by the action of strong oxidizing agents under acid conditions. Organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. One of the chief limitations is its inability to differentiate between biologically oxidizable and biologically inert organic matter. The major advantage of this test is the short time required for evaluation (2 hours). (2) The amount of oxygen required for the chemical oxidation of organics in a liquid.

Chemical Precipitation - (1) Formation of insoluble materials generated by addition of chemicals to a solution. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

Chlorination - The application of chlorine to water or wastewater generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Circuit Breaker - Device capable of making, carrying, and breaking currents under normal or abnormal circuit conditions.

Cleaning - The removal of soil and dirt (including grit and grease) from a workpiece using water with or without a detergent or other dispersing agent.

Coil - A number of furns of wire used to introduce inductance into an electric circuit, to produce magnetic flux, or to react mechanically to a changing magnetic flux.

Coil-Core Assembly - A unit made up of the coil windings of a transformer placed over the magnetic core.

Coking - (1) Destructive distillation of coal to make coke. (2) A process for thermally converting the heavy residual bottoms of crude oil entirely to lower-boiling petroleum products and by-product petroleum coke.

Colloids - A finely divided dispersion of one material called the "dispersed phase" (solid) in another material called the "dispersion medium" (liquid). Normally negatively charged.

Composite Wastewater Sample - A combination of individual samples of water or wastewater taken at selected intervals and mixed in proportion to flow or time to minimize the effect of the variability of an individual sample.

Concentric Windings - Transformer windings in which the low-voltage winding is in the form of a cylinder next to the core, and the high-voltage winding, also cylindrical, surrounds the lowvoltage winding.

Conductor - A wire, cable, or other body or medium suitable for carrying electric current.

Conduit - Tubing of flexible metal or other material through which insulated electric wires are run.

Contamination - A general term signifying the introduction into water of microorganisms, chemicals, wastes or sewage which renders the water unfit for its intended use.

Contractor Removal - The disposal of oils, spent solutions, or sludge by means of a scavenger service.

Conversion Coating - As metal-surface coating consisting of compound of the base metal.

Cooling Tower - A device used to cool manufacturing process water before returning the water for reuse.

Copper - A common, reddish, chiefly univalent and bivalent metallic element that is ductile and malleable and one of the best conductors of heat and electricity.

Core (Magnetic Core) - A quantity of ferrous material placed in a coil or transformer to provide a better path than air for magnetic flux, thereby increasing the inductance of the coil or increasing the coupling between the windings of a transformer.

Corona Discharge - A discharge of electricity appearing as a bluishpurple glow on the surface of an adjacent to a conductor when the voltage gradient exceeds a certain critical value; caused by ionization of the surrounding air by the high voltage.

Curing - A heating/drying process carried out in an elevated-temperature enclosure.

Current Carrying Capacity - The maximum current that can be continuously carried without causing permanent deterioration of electrical or mechanical properties of a device or conductor.

Dag (Aquadag) - A conductive graphite coating on the inner and outer side walls of some cathode-ray tubes.

Degreasing - The process of removing grease and oil from the surface of the basis material.

Dewatering - A process in which water is removed from sludge.

Dicing - Sawing or otherwise machining a semiconductor wafer into small squares or dice from which transistors and diodes can be fabricated.

Die - A tool or mold used to cut shapes to or form impressions on materials such as metals and ceramics.

Die Cutting (Also Blanking) - Cutting of plastic or metal sheets into shapes by striking with a punch.

Dielectric - A material that is highly resistant to the conductance of electricity; an insulator.

Di-n-octyl-phthalate - A liquid dielectric that is presently being substituted for a PCB dielectric fluid.

Diode (Semiconductor), (Also Crystal Diode, Crystal Rectifier) - A two-electrode semiconductor device that utilizes the rectifying properties of a p-n junction or point contact.

Discrete Device - Individually manufactured transistor, diode, etc.

Dissolved Solids - Theoretically the anhydrous residues of the dissolved constituents in water. Actually the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

Distribution Transformer - An element of an electric distribution system located near consumers which changes primary distribution voltage to a lower consumer voltage.

Dopant - An impurity element added to semiconductor materials used in crystal diodes and transistors.

Dragout - The solution that adheres to the part of workpiece and is carried past the edge of the tank.

Dry Electrolytic Capacitor - An electrolytic capacitor with a paste rather than liquid electrolyte.

Drying Beds - Areas for dewatering of sludge by evaporation and seepage.

Dry Slug - Usually refers to a plastic-encased sintered tantalum slug type capacitor.

Dry Transformer - Having the core and coils neither impregnated with an insulating fluid nor immersed in an insulating oil.

Effluent - The quantities, rates, and chemical, physical, biological and other constituents of waters which are discharged from point sources.

Electrochemical Machining - Shaping of an anode by the following process: The anode and cathode are placed close together and electrolyte is pumped into the space between them. An electrical potential is applied to the electrodes causing anode metal to be dissolved selectively, producing a shaped anode that complements the shape of the cathode.

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Electrolyte - A nonmetallic electrical conductor in which current is carried by the movement of ions.

Electron Beam Lithography - Similar to photolithography - A fine beam of electrons is used to scan a pattern and expose an electronsensitive resist in the unmasked areas of the object surface.

Electron Discharge Lamp - An electron lamp in which light is produced by passage of an electric current through a metallic vapor or gas.

Electron Gun - An electrode structure that produces and may control, focus, deflect and converge one or more electron beams in an electron tube.

Electron Tube - An electron device in which conduction of electricity is accomplished by electrons moving through a vacuum of gaseous medium within a gas-tight envelope.

Electroplating - The production of a thin coating of one metal on another by electrode position.

Emissive Coating - An oxide coating applied to an electrode to enhance the emission of electrons.

Emulsion Breaking - Decreasing the stability of dispersion of one liquid in another.

End-of-Pipe Treatment - The reduction and/or removal of pollutants by chemical treatment just prior to actual discharge.

Epitaxial Layer - A (thin) semiconductor layer having the same crystaline orientation as the substrate on which it is grown.

Epitaxial Transistor - Transistor with one or more epitaxial layers.

Equalization - The process whereby waste streams from different sources varying in pH, chemical constituents, and flow rates are collected in a common container. The effluent stream from this equalization tank will have a fairly constant flow and pH level, and will contain a homogeneous chemical mixture. This tank will help to prevent unnecessary shock to the waste treatment system.

Etch - To corrode the surface of a metal in order to reveal its composition and structure.

Extrusion - Forcing the carbon-binder-mixture through a die under extreme pressure to produce desireable shapes and characteristics of the piece.

Field-effect Transistors - Transistors made by the metal-oxide-semiconductor (MOS) technique, differing from bipolar ones in that only one kind of charge carrier is active in a single device. Those that employ electrons are called n-MOS transistors; those that employ holes are p-MOS transistors.

Filament - (1) Metallic wire which is heated in an incandescent lamp to produce light by passing an electron current through it. (2) A cathode in a fluorescent lamp that emits electrons when electric current is passed through it.

Filtering Capacitor - A capacitor used in a power-supply filter system to provide a low-reactance path for alternating currents and thereby suppress ripple currents, without affecting direct currents.

Fixed Capacitor - A capacitor having a definite capacitance value that cannot be adjusted.

Float Gauge - A device for measuring the elevation of the surface of a liquid, the actuating element of which is a buoyant float that rests on the surface of the liquid and rises or falls with it. The elevation of the surface is measured by a chain or tape attached to the float.

Floc - A very fine, fluffy mass formed by the aggregation of fine suspended particles.

Flocculation - In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means. In biological wastewater treatment where coagulation is not used, agglomeration may be accomplished biologically.

Flocculator - An apparatus designed for the formation of floc in water or sewage.

Flow-proportioned Sample - A sampled stream whose pollutants are apportioned to contributing streams in proportion to the flow rates of the contributing streams.

Fluorescent Lamp - An electric discharge lamp in which phosphor materials transform ultraviolet radiation from mercury vapor ionization to visible light.

Forming - Application of voltage to an electrolytic capacitor, electrolytic rectifier or semiconductor device to produce a desired permanent change in electrical characteristics as part of the manufacturing process.

Frit Seal - A seal made by fusing together metallic powders with a glass binder for such applications as hermatically sealing ceramic packages for integrated circuits.

Funnel - The rear, funnel-shaped portion of the glass enclosure of a cathode ray tube.

Fuse - Overcurrent protective device with a circuit-opening fusible part that would be heated and severed by overcurrent passage.

Gate - One of the electrodes in a field effect transistor.

Getter - A metal coating inside a lamp which is activated by an electric current to absorb residual water vapor and oxygen.

Glass - A hard, amorphous, inorganic, usually transparent, brittle substance made by fusing silicates, and sometimes borates and phosphates, with certain basic oxides and then rapidly cooling to prevent crystallization.

Glow Lamp - An electronic device, containing at least two electrodes and an inert gas, in which light is produced by a cloud of electrons close to the negative electrode when a voltage is applied between the electrodes.

Grab Sample - A single sample of wastewater taken at an "instant" in time.

Graphite - A soft black lustrous carbon that conducts electricity and is a constituent of coal, petroleum, asphalt, limestone, etc.

Grease - In wastewater, a group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oil and certain other nonfatty materials. The type of solvent and method used for extraction should be stated for quantification.

Grease Skimmer - A device for removing grease or scum from the surface of wastewater in a tank.

Green Body - An unbaked carbon rod or piece that is usually soft and quite easily broken.

Grid - An electrode located between the cathode and anode of an electron tube, which has one or more openings through which electrons or ions can pass, and which controls the flow of electrons from cathode to anode.

Grinding - The process of removing stock from a workpiece by the use of abrasive grains held by a rigid or semi-rigid binder.

Hardness - A characteristic of water, imparted by calcium, magnesium, and ion salts such as bicarbonates, carbonates, sulfates, chlorides, and nitrates. These cause curdling of soap, deposition of scale in boilers, damage in some industrial processes and sometimes objectionable taste. Hardness may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc, and is expressed as equivalent calcium carbonate.

Heavy Metals - A genral name given to the ions of metallic elements such as copper, zinc, chromium, and nickel. They are normally removed from wastewater by an insoluble precipitate (usually a metallic hydroxide).

Holding Tank - A reservoir to contain preparation materials so as to be ready for immediate service.

Hybrid Integrated Circuits - A circuit that is part integrated and part discrete.

Impact Extrusion - A cold extrusion process for producing tubular components by striking a slug of the metal, which has been placed in the cavity of the die, with a punch moving at high velocity.

Impregnate - To force a liquid substance into the spaces of a porous solid in order to change its properties.

Incandescent Lamp - An electric lamp producing light in which a metallic filament is heated white-hot in a vacuum by passage of an electric current through it.

Industrial Wastes - The liquid wastes from industrial processes as distinct from domestic or sanitary wastes.

Influent - Water or other liquid, either raw or partly treated, flowing into a reservoir basin or treatment plant.

In-Process Control Technology - The regulation and conservation of chemicals and rinse water at their point of use as opposed to end-of-pipe treatment.

Insulating Paper - A standard material for insulating electrical equipment, usually consisting of bond or kraft paper coated with black or yellow insulating varnish on both sides.

Insulation (Electrical Insulation) - A material having high electrical resistivity and therefore suitable for separating adjacent conductors in an electric circuit or preventing possible future contact between conductors.

Insulator - A nonconducting support for an electric conductor.

Integrated Circuit - Assembly of electronic devices interconnected into circuits.

Interleaved Winding - An arrangement of winding coils around a transformer core in which the coils are wound in the form of a disk, with a group of disks for the low-voltage windings stacked alternately with a group of discks for the high-voltage windings.

Intermittent Filter - A natural or artificial bed of sand or other fine-grained material onto which sewage is intermittently flooded and through which it passes, with time allowed for filtration and the maintenance of aerobic conditions.

Ion Exchange - A reversible chemical reaction between a solid (ion exchanger) and a fluid (usually a water solution) by means of which ions may be interchanged from one substance to another. The superficial physical structure of the solid is not affected.

Ion Exchange Resins - Synthetic resins containing active groups (usually sulfonic, carboxylic, phenol, or substituted amino groups) that give the resin the ability to combine with or exchange ions with a solution.

Ion Implantation - A process of introducing impurities into the near surface regions of solids by directing a beam of ions at the solid.

Junction - A region of transition between two different semiconducting regions in a semiconductor device such as a p-n junction, or between a metal and a semiconductor.

Junction Box - A protective enclosure into which wires or cables are led and connected to form joints.

Knife Switch - Form of switch where moving blade enters stationary contact clips.

Klystron - An evacuated electron-beam tube in which an initial velocity modulation imparted to electrons in the beam results subsequently in density modulation of the beam; used as an amplifier in the microwave region or as an oscillator.

Lagoon - A man-made pond or lake for holding wastewater for the removal of suspended solids. Lagoons are also used as retention ponds after chemical clarification to polish the effluent and to safeguard against upsets in the clarifier; for stabilization of organic matter by biological oxidation; for storage of sludge; and for cooling of water.

Landfill - The disposal of inert, insoluble waste solids by dumping at an approved site and covering with earth.

Lapping - The mechanical abrasion or surface planing of the semiconductor wafer to produce desired surface and wafer thickness.

Lime - Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) which is composed almost wholly of calcium carbonates or a mixture of calcium and magnesium carbonates.

Limiting Orifice - A device that limits flow by constriction to a relatively small area. A constant flow can be obtained over a wide range of upstream pressures.

Machining - The process of removing stock from a workpiece by forcing a cutting tool through the workpiece and removing a chip of basis material. Machining operatings such as tuning, milling, drilling, boring, tapping, planing, broaching, sawing and cutoff, shaving, threading, reaming, shaping, slotting, hobbing, filling, and chambering are included in this definition.

Magnaflux Inspection - Trade name for magnetic particle test.

Make-up Water - Total amount of water used by any process/process step.

Mandrel - A metal support serving as a core around which the metals are wound and aneal1ed to form a central hole.

Mask (Shadow Mask) - Thin sheet steel screen with thousands of apertures through which electron beams pass to a color picture tube screen. The color of an image depends on the balance from each of three different electron beams passing through the mask.

Metal Oxide Semiconductor Device - A metal insulator semiconductor structure in which the insulating layer is an oxide of the substrate material; for a silicon substrate, the insulating layer is silicon dioxide (SiO_2).

Mica - A group of aluminum silicate minerals that are characterized by their ability to split into thin, flexible flakes because of their basal cleavage.

Miligrams Per Liter (mg/l - This is a weight per volume designation used in water and wastewater analysis.

Mixed Media Filtration - A filter which uses two or more filter materials of differing specific gravities selected so as to produce a filter uniformly graded from coarse to fine.

MOS - (See Metal Oxide Semiconductor).

Mount Assembly - Funnel neck ending of picture tube holding electron gun(s).

National Pollutant Discharge Elimination System (NPDES) - The federal mechanism for regulating point source discharge by means of permits.

Neutralization - Chemical addition of either acid or base to a solution such that the pH is adjusted to approximately 7.

Noncontact Cooling Water - Water used for cooling which does not come into direct contact with any raw material, intermediate product, waste product or finished product.

Oil-Filled Capacitor - A capacitor whose conductor and insulating elements are immersed in an insulating fluid that is usually, but not necessarily, oil.

Outfall - The point or location where sewage or drainage discharges from a sewer, drain, or conduit.

Oxide Mask - Oxidized layer of silicon wafer through which "windows" are formed which will allow for dopants to be introduced into the silicon.

Panel - The front, screen portion of the glass enclusre of a cathode ray tube.

PCB (Polychlorinated Biphenyl) - A colorless liquid, used as an insulating fluid in electrical equipment. (The future use of PCB for new transformers was banned by the Toxic Substances Control Act of October 1976).

pH - The negative of the logarithm of the hydrogen ion concentration. Neutral water has a pH value of 7. At pH lower than 7, a solution is acidic. At pH higher than 7, a solution is alkaline.

pH Adjustment - A means of maintaining the optimum pH through the use of chemical additives. Can be manual, automatic, or automatic with flow corrections.

Phase - One of the separate circuits or windings of a polyphase system, machine or other appartus.

Phase Assembly - The coil-core assembly of a single phase of a transformer.

Phosphate Coating - A conversion coating on metal, usually steel, produced by dipping it into a hot aqueous solution of iron, zinc, or manganese phosphate.

Phosphor - Crystalline inorganic compounds that produce light when excited by ultraviolet radiation.

Photolithography - The process by which a microscopic pattern is tranferred from a photomask to a material layer (e.g., SiO_2) in an actual circuit.

Photomask - A film or glass negative that has many high-resolution images, used in the production of semiconductor devices and integrated circuits.

Photon - A quantum of electromagnetic energy.

Photoresist - A light-sensitive coating that is applied to a substrate or board, exposed, and developed prior to chemical etching; the exposed areas serve as a mask for selective etching.

Picture Tube - A cathode ray tube used in television receivers to produce an image by varying the electron beam intensity as the beam scans a fluorescent screen.

Plate - (1) Preferably called the anode. The principal electrode to which the electron stream is attracted in an electron tube. (2) One of the conductive electrodes in a capacitor.

Polar Capacitor - An electrolytic capacitor having an oxide film on only one foil or electrode which forms the anode or positive terminal.

Pole Type Transformer - A transformer suitable for mounting on a pole or similar structure.

Poling - A step in the production of ceramic piezoelectric bodies which orients the oxes of the crystallites in the preferred direction.

Polishing - The process of removing stock from a workpiece by the action of loose or loosely held abrasive grains carried to the workpiece by a flexible support. Usually, the amount of stock removed in a polishing operation is only incidental to achieving a desired surface finish or appearance.

Pollutant - The term "pollutant" means dredged spoil, solid wastes, incinerator residue, sewage, grabage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water.

Pollutant Parameters - Those constituents of wastewater determined to be detrimental and, therefore, requiring control.

Pollution Load - A measure of the unit mass of a wastewater in terms of its solids or oxygen-demanding characteristics, or in terms of harm to receiving waters.

Polyelectrolytes - Synthetic or natural polymers containing ionic constituents, used as a coagulant or a coagulant aid in water and wastewater treatment.

Power Regulators - Transformers used to maintain constant output current for changes in temperature output load, line current and time.

Power Transformer - Transformer used at a generating station to step up the initial voltage to high levels for transmission.

Prechlorination - (1) Chlorination of water prior to filtration. (2) Chlorination of sewage prior to treatment.

Precipitate - The discrete particles of material settled from a liquid solution.

Pressure Filtration - The process of solid/liquid phase separation effected by passing the more permeable liquid phase through a mesh which is impenetrable to the solid phase.

Pretreatment - Any wastewater treatment process used to reduce pollution load partially before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Primary Feeder Circuit (Substation) Transformers - These transformers (at substations) are used to reduce the voltage from the subtransmission level to the primary feeder level.

Primary Treatment - A process to remove substantially all floating and settleable solids in wastewater and partially to reduce the concentration of suspended solids.

Primary Winding - Winding on the supply (i.e., input) side of a transformer.

Priority Pollutant - The 129 specific pollutants established by the EPA from the 65 pollutants and classes of pollutants as outlined in the consent decree of June 8, 1976.

Process Wastewater - Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw materials, intermediate product, finished product, by-product, or waste product.

Process Water - Water prior to its direct contact use in a process or operation. (This water may be any combination of a raw water, service water, or either process wastewater or treatment facility effluent to be recycled or reused.)

Pyrolysis - The breaking apart of complex molecules into simpler units by the use of heat, as in the pyrolysis of heavy oil to make gasoline.

Quenching - Shock cooling by immersion of liquid of molten material in a cooling medium (liquid or gas). Used in metallurgy, plastics forming, and petroleum refining.

Raceway - A channel used to hold and protect wires, cables or busbars.

Rapid Sandfilter - A filter for the purification of water where water which has been previously treated, usually be coagulation and sedimentation, is passed through a filtering medium consisting of a layer of sand or prepared anthracite coal or other suitable material, usually from 24 to 30 inches thick and resting on a supporting bed of gravel or a porous medium such as carborundum. The filtrate is removed by a drain system. The filter is cleaned periodically by reversing the flow of the water through the filtering medium. Sometimes supplemented by mechanical or air agitation during backwashing to remove mud and other impurities.

Raw Wastewater - Plant water prior to any treatment or use.

Rectifier - (1) A device for converting alternating current into direct current. (2) a nonlinear circuit component that, ideally, allows current to flow in one direction unimpeded but allows no current to flow in the other direction.

Recycled Water - Process wastewater or treatment facility effluent which is recirculated to the same process.

Resistor - A device designed to provide a definite amount of resistance, used in circuits to limit current flow or to provide a voltage drop.

Retention Time - The time allowed for solids to collect in a settling tank. Theoretically retention time is equal to the volume of the tank divided by the flow rate. The actual retention time is determined by the purpose of the tank. Also, the design residence time in a tank or reaction vessel which allows a chemical reaction to go to completion, such as the reduction of hexavalent chromium or the destruction of cyanide.

Reused Water - Process wastewater or treatment facility effluent which is further used in a different manufacturing process.

Rinse - Water for removal of dragout by dipping, spraying, fogging etc.

Sanitary Sewer - A sewer that carriers liquid and water wastes from residences, commercial buildings, industrial plants, and institutions together with ground, storm, and surface waters that are not admitted intentionally.

Sanitary Water - The supply of water used for sewage transport and the continuation of such effluents to disposal.

Secondary Settling Tank - A tank through which effluent from some prior treatment process flows for the purpose of removing settleable solids.

Secondary Wastewater Treatment - The treatment of wastewater by biological methods after primary treatment by sedimentation.

Secondary Winding - Winding on the load (i.e. output) side of a transformer.

Sedimentation - Settling of matter suspended in water by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Semiconductor - A solid crystalline material whose electrical conductivity is intermediate between that of a metal and an insulator.

Settleable Solids - (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as one hour, but either settles to the bottom or floats to the top. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour.

Sewer - A pipe or conduit, generally closed, but normally not flowing full, for carrying sewage and other waste liquids.

Silvering - The deposition of thin films of silver on glass, etc. carried by one of several possible processes.

Skimming Tank - A tank so designed that floating matter will rise and remain on the surface of the wastewater until removed, while the liquid discharges continuously under walls or scum boards.

Sludge - The solids (and accompanying water and organic matter) which are separated from sewage or industrial wastewater.

Sludge Cake - The material resulting from air drying or dewatering sludge (usually forkable or spadable).

Sludge Disposal - The final disposal of solid wastes.

Sludge Thickening - The increase in solids concentration of sludge in a sedimentation or digestion tank.

Snubber - Shock absorber.

Soldering - The process of joining metals by flowing a thin (capillary thickness) layer of nonferrous filler metal into the space between them. Bonding results from the intimate contact produced by the dissolution of a small amount of base metal in the molten filler metal, without fusion of the base metal.

Solvent - A liquid capable of dissolving or dispersing one or more other substances.

Solvent Degreasing - The removal of oils and grease from a workpiece using organic solvents or solvent vapors.

Sputtering - A process to deposit a thin layer of metal on a solid surface in a vacuum. Ions bombard a cathode which emits the metal atoms.

Stacked Capacitor - Device containing multiple layers of dielectric and conducting materials and designed to store electrical charge.

Stamping - Almost any press operations including blanking, shearing, hot or cold forming, drawing, blending, or coining.

Steel - An iron-based alloy, malleable under proper conditions, containing up to about 2% carbon.

Step-Down Transformers - (Substation) - A transformer in which the AC voltages of the secondary windings are lower than those applied to the primary windings.

Step-Up Transformer - Transformer in which the energy transfer is from a low-voltage primary (input) winding to a high-voltage secondary (output) winding or windings.

Studs - Metal pins in glass of picture tube onto which shadow mask is hung.

Substation - Complete assemblage of plant, equipment, and the necessary buildings at a place where electrical energy is received (from one more power-stations) for conversion (e.g., from AC to DC by means of rectifiers, rotary converters), for stepping-up or down by means of transformers, or for control (e.g. by means of switch-gear, etc.).

Subtransmission (Substation) Transformers - At the end of a transmission line, the voltage is reduced to the subtransmission level (at substations) by subtransmission transformers.

Suspended Solids - (1) Solids that are either floating or in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as non-filterable residue.

Tantalum - A lustrous, platinum-gray ductile metal used in making dental and surgical tools, penpoints, and electronic equipment.

Tantalum Foil - A thin sheet of tantalum, usually less than 0.006 inch thick.

Terminal - A screw, soldering lug, or other point to which electric connections can be made.

Testing - A procedure in which the performance of a product is measured under various conditions.

Thermoplastic Resin - A plastic that solidifies when first heated under pressure, and which cannot be remelted or remolded without destroying its original characteristics; examples are epoxides, melamines, phenolics and ureas.

Transformer - A device used to transfer electric energy, usually that of an alternating current, from one circuit to another; especially, a pair of multiply-wound, inductively coupled wire coils that effect such a transfer with a change in voltage, current, phases, or other electric characteristics.

Transistor - An active component of an electronic circuit consisting of a small block of semiconducting material to which at least three electrical contacts are made; used as an amplifier, detector, or switch.

Trickling Filter - A filter consisting of an artificial bed of coarse material, such as broken stone, clinkers, slats, or brush over which sewage is distributed and applied in drops, films, or spray, from troughs, drippers, moving distributors or fixed nozzles and through which it trickles to the underdrain giving opportunity for the formation of zoogleal slimes which clarify the oxidized sewage.

Trimmer Capacitors - These are relatively small variable capacitors used in parallel with larger variable or fixed capacitors to permit exact adjustment of the capacitance of the parallel combination.

Vacuum Filter - A filter consisting of a cylindrical drum mounted on horizontal axis, covered with a filter cloth revolving with a partial submergence in liquid. A vacuum is maintained under the cloth for the larger part of a revolution to extract moisture and the cake is scraped off continuously.

Vacuum Metalizing - The process of coating a workpiece with metal by flash heating metal vapor in a high-vacuum chamber containing the workpiece. The vapor condenses on all exposed surfaces.

Vacuum Tube - An electron tube vacuated to such a degree that its electrical characteristics are essentially unaffected by the presence of residual gas or vapor.

Variable Capacitor - A device whose capacitance can be varied continuously by moving one set of metal plates with respect to another.

Voltage Breakdown - The voltage necessary to cause insulation failture.

Voltage Regulator - Like a transformer, it corrects changes in current to provide continuous, constant current flow.

Welding - The process of joining two or more pieces of material by applying heat, pressure or both, with or without filler material, to produce a localized union through fusion or recrystallization across the interface.

Wet Air Scrubber - Air pollution control device which uses a liquid or vapor to absorb contaminants and which produces a wastewater stream.

Wet Capacitor - (See oil-filled capacitor).

Wet Slug Capacitor - Refers to a sintered tantalum capacitor where the anode is placed in a metal can, filled with an electrolyte and then sealed.

Wet Tantalum Capacitor - A polar capacitor the cathode of which is a liquid electrolyte (a highly ionized acid or salt solution).

Wet Transformer - Having the core and coils immersed in an insulating oil.

Yoke - A set of coils placed over the neck of a magnetically deflected cathode-ray tube to deflect the electron beam horizontally and vertically when suitable currents are passed through the coils.